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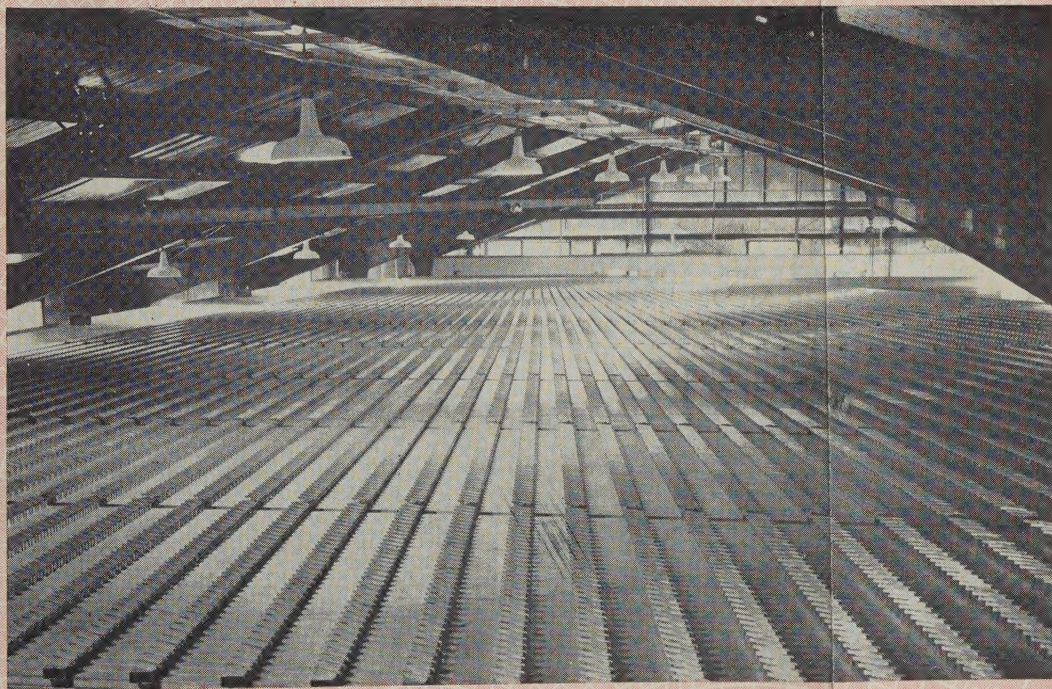
- Shnitkin — Survey of Electronically Scanned Antennas
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- Aleksandrov, Gorskaya, Gershenzon, & Erkin — Control of the Amplitude and Phase of an Electromagnetic Wave in a Waveguide by Means of a Germanium Plate

the

microwave

journal

DR BERNARD HERZOG
PHILCO CORP-C & I DIV
3875 PASADENA WAY
PALO ALTO CALIF
VII TFAJ5A9/61



Also In This Issue . . .

INDEX FOR VOLUME III

presenting 182 high quality



FULL-RANGE TESTED

microwave
measuring
instruments

Your **hp** representative offers two very important advantages

- the world's most complete (and rapidly expanding) microwave line
- complete assurance that the equipment will perform precisely as specified

hp makes sure you get what you pay for by rigid quality control plus 100% electrical testing using **hp** developed methods including reflectometer and swept frequency techniques. **hp** knows when a parameter is out of spec; never gambles your money and time that 3 or 4 sample measurements taken across an instrument's range truly indicate its full-range performance.

See your **hp** rep now for FULL-RANGE TESTED microwave equipment... *get what you pay for.*



FREE
TEST METHOD
DESCRIPTION

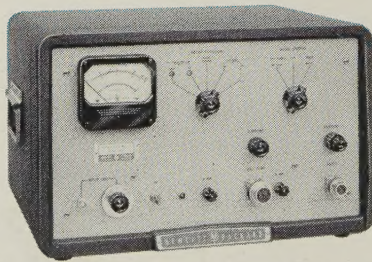
Interested in swept frequency testing? Ask your rep, or write direct for "Application Note 42," **hp** 416A Ratio Meter, describing reflectometer systems and **hp** swept frequency measuring techniques.

NEW **hp** NOISE MEASURING EQUIPMENT



hp 344A Noise Figure Meter

Quickly, accurately measures noise figure of operating radar sets. Automatic operation; simple front panel calibration. Militarized, transistorized, reliable in extreme environments, minimum size and weight. Continuous noise figure presentation on most radar receivers. Extremely high sensitivity permits decoupling noise source up to 20 db from main transmitter line to minimize system degradation. Provision for automatic alarm, remote noise figure monitoring, modulating. Meter scale/excess noise options; 25 or 30 MC input frequency, 1 MC bandwidth, 75 ohms input impedance. Approx. \$1,600.00 (depending on options and modifications selected).



hp 340B/342A Noise Figure Meters

General-purpose instruments making possible, in minutes, receiver and component alignment jobs that once took hours. Simplifies accurate alignment; encourages better maintenance; better performance.

hp 340B automatically measures, continuously displays IF or rf amplifier noise figure at 30 or 60 MC; other freq. on order. \$715.00 (cabinet) \$700.00 (rack).

hp 342A, similar, operates on 30, 60, 70, 105, 200 MC. 30 MC and 4 other frequen-

cies between 38 and 200 MC on order \$815.00 (cabinet) \$800.00 (rack). (Note: Models 340B and 342A available only in the U.S.A. and Canada)

hp 343A vhf Noise Source, temperature limited diode broadband source, 10 to 600 MC, 5.2 db excess noise, \$100.00.

hp 345B IF Noise Source, 30 or 60 MC (others to order); 4 impedances, 5.2 db excess noise. \$75.00.

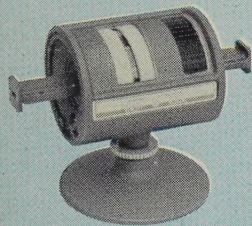
hp 347A Waveguide Noise Source, Argon gas discharge tubes in waveguide section; for bands S, G, J, H, X, K, 2.6 to 18.0 KMC, 15.2 db excess noise. \$190.00 to \$250.00.

Basic test, power and
impedance measuring
equipment



World's largest line of FULL-RANGE

BASIC TEST EQUIPMENT



382A Precision Attenuators

Popular 382A series precision attenuators now include in "K" and "R" bands, 18.0 to 40.0 KMC. "K", "R" band attenuators are of new, space-saving design (see photo). Direct reading, one-control setting, high power handling capacity. Attenuation 0 to 50 db full range, independent of frequency. Phase shift constant with attenuation. G, J, H, X, M, P, K, R bands, \$275.00 to \$500.00.



421A, 420A/B Crystal Detectors

421A (shown), silicon crystal detector of rf signals in waveguide systems. High sensitivity, for H, X, P bands, 7.05 to 18.0 KMC. 421A, \$75.00 to \$135.00. 420A, similar but for Type N coax lines, 10 MC to 12.5 KMC. \$50.00 each. Also 420B, same in matched pairs, \$150.00 pair.

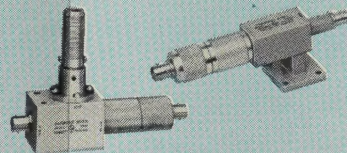
532 Waveguide Frequency Meters

New design for G, H, J, M, P, K, R bands. Wide band, direct reading, no interpolation or charts. Has a high Q resonant cavity tuned by choke plunger; no sliding contacts. Transmits almost full power at resonance; resonance indicated by 1.5 db dip in output. Similar model for X-band. \$150.00 to \$275.00.



914 Moving Loads

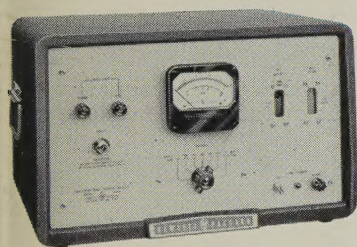
Waveguide section containing sliding, tapered, low-reflection load. Plunger controls load position, travels 1/2 wavelength at lowest frequency to reverse phase of residual load reflection. Models for S, G, J, H, X, M, P, K, R bands, 2.6 to 40.0 KMC. \$55.00 to \$250.00.



P932A/934A Harmonic Mixers

Mixer for wide band beat detecting, beat frequency mixer for stabilizing a signal source. P932A 12.4 to 18.0 KMC; 934A (coaxial) covers 2 to 12.4 KMC. Both models: max. input power 100 mw. P932A, \$250.00 934A, \$150.00.

POWER MEASURING EQUIPMENT



434A Calorimetric Power Meter

Connect and read powers 10 mw to 10 watts, dc to 12.4 KMC. No barretter, thermistor needed, no external terminations or plumbing. Measures CW or pulsed power. Two simple controls. Dc input imped-

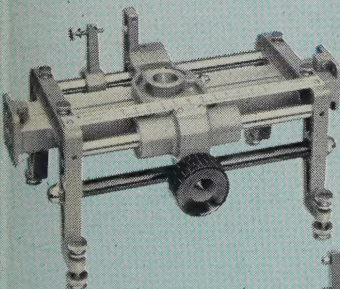
ance 50 ohms approx.; input SWR less than 1.7 full range, less than 1.3 to 5 KMC. Accuracy within 5% full scale. \$1,400.00 (cabinet) \$1,385.00 (rack mount).



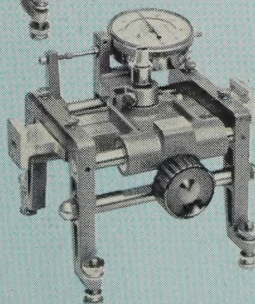
430C Microwave Power Meter

No computations! Provides instantaneous, automatic power readings *direct* in dbm or mw at all frequencies for which there are suitable bolometer mounts. For CW measurements, uses either 1/100 amp fuse or Sperry 821 barretter. Also measures CW or pulsed power with negative coefficient thermistor. Provides up to 16 ma bias current. Operates with 475, 476, 477, 485, 487 mounts. Range 0.01 to 10 mw. \$250.00 (cabinet) \$255.00 (rack mount).

IMPEDANCE MEASURING EQUIPMENT



-hp- 809B and 810B



-hp- 814B, 815B, 446B

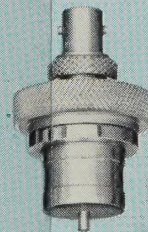
809B/814B Universal Probe Carriages

Models 809B and 814B are precision built mechanical assemblies operating, respectively, with 810B and 815B series slotted sections.

Combination of the 809B carriage and 810 slotted sections covers 2.6 to 18.0 KMC. Combination of 814B carriage and 815B series sections covers 18.0 to 40.0 KMC.

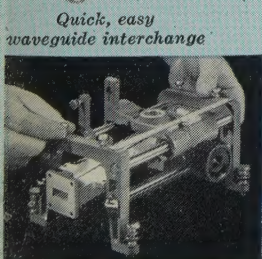
On either carriage, waveguides can be interchanged in seconds. Only one probe (for each carriage) covers full frequency range. Manufacture is of highest quality, assures positive mechanical positioning of interchangeable waveguides and precise installation of mating probes. 809B has vernier scale reading to 0.1 mm, is equipped for dial gauge mounting. 814B has dial read directly to 0.1 mm. 809B, \$160.00, 814B, \$200.00

444A/446B Untuned Probes



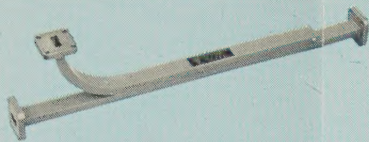
444A (shown) is modified crystal (1N76 or 1N26) plus small antenna in convenient housing. Probe penetration easily variable; locks in position. No tuning; sensitivity superior to elaborate single, double

tuned probes. Range 3.0 to 18 KMC; fits 3/4" bore. New 446B for 814 Probe Carriage, similar but covers K and R bands, 18.0 to 40.0 KMC. 444A, \$40.00. 446B, \$145.00. 446B also offers model 440A, for barretter or crystal, Type N coaxial, \$85.00.



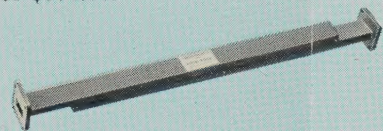
Quick, easy waveguide interchange

TESTED waveguide and coaxial equipment



752 Multi-Hole Coupler

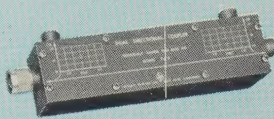
Precision directional couplers, 3 models, coupling factors 3, 10 and 20 db. Coupling accuracy ± 0.4 db or 0.7 db. Directivity better than 40 db full range, SWR less than 1.1 (752A), 1:05 (752 C/D). S through R bands, 2.6 to 40.0 KMC. \$100.00 to \$375.00.



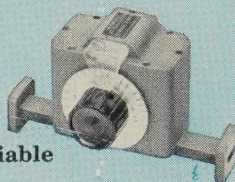
372 Precision Attenuators

Rugged, broadband fixed attenuators retaining precise calibration regardless of humidity, temperature or time. Invariant attenuation assured by permanent, "multi-hole coupler" joining of two waveguides. 10 and 20 db models for S, G, J, H, X and P bands, 2.6 to 18.0 KMC. \$100.00 to \$375.00.

764D-767D Dual Directional Couplers



High directivity dual coaxial couplers make reflectometer measurements practical in vhf and uhf coax systems. Flat response, high power capacity, low insertion loss. Four models, covering 216 to 4,000 MC collectively. 764D/765D \$160.00. 766D/767D \$150.00.



375A Variable Flap Attenuators

Simple, convenient for adjusting waveguide power or isolating source and load. Max. SWR less than 1.15 full range; attenuation variable 0 to 20 db, dissipates average powers up to 0.5 or 1 watt. S through R bands, 2.6 to 40.0 KMC. \$90.00 to \$180.00.



870A Slide Screw Tuner

For flatter waveguide systems, match etc. Probe location, penetration, adjusts to reflection canceling existing reflection. Precision lead screw micrometer varies probe insertion; vernier adjusts probe position. Corrects SWR 20 with accuracy of 1.02 SWR. For J, H, X, M, P, K, R bands. 2.6 to 40.0 KMC. \$125.00 to \$300.00.

362A Low Pass Filter

Compact models increase SWR measurement accuracy by suppressing harmonics; feature low insertion loss, broad stop band; 100 dB Band models, each \$125.00.

WR75 Components—10 to 15 KMC

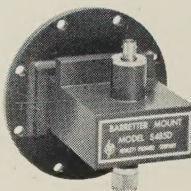
An increasing number of precision waveguide instruments shown here are available in M-band, recently allocated for private microwave communications.

See your **hp** catalog for general description, call your **hp** representative for prices, details.

476A, 477B Detector Mounts

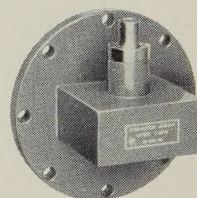


476A Universal Bolometer Mount, for rf power measurement 10 to 1,000 MC; no tuning, SWR less than 1.25. \$85.00. 477B Coaxial Thermistor Mount (shown) for rf power measurement 10 MC to 10 KMC; no tuning, SWR less than 1.5, \$75.00.



485 Detector Mounts

Three basic series offered: S485A for S band (no tuning, 1.35 SWR, 821 element); 485B, for G, J, H, X bands (tunable, uses 1N23, 1N21, 821 element, 1.25 SWR using barretter); 485D for S, G, J bands (factory-installed 821 barretter). \$75.00 to \$170.00.



487B Thermistor Mounts

Each covers full range of its waveguide. No tuning, SWR 1.5 or 2.0. Max. power 10 mw. Rugged construction, positive temperature coefficient thermistors virtually eliminate burnout. G through R bands. 2.6 to 40.0 KMC. \$75.00 to \$225.00.

810/815B Slotted Sections

810B Slotted Sections 810B, for 809B carriage, flanged, waveguide section with accurately machined slot. Slot tapered at ends to minimize reflection. Available in 6 waveguide bands (including M-band), 3.95 through 18.0 KMC. \$90.00 to \$110.00.

810A. Complete slotted section assembly including probe carriage. In 2.6 to 3.95 KMC (S-band) size only. \$450.00.

815B Slotted Sections Formounting in 814B carriage. Available K and R bands, 18.0 to 40.0 KMC. Accurately machined; easy interchange, precise positioning. \$265.

806B Coaxial Slotted Section 3 to 12 KMC, mounts in 809B, has Type N connectors. \$200.00.

805A/B Slotted Lines

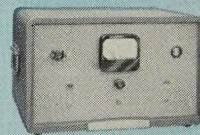
Utmost mechanical rigidity, less leakage, greater accuracy, SWR 1.02 or 1.04. Range 500 MC to 4 KMC, reads in cm and mm to 0.1 mm. 805A, for 50 ohm Type N, 805B, for 46.3 ohm RG 44/U. 805A/B, \$450.00.



415B Standing Wave Indicator

For all waveguide and coaxial slotted sections. Gives readings in SWR or db. Single frequency operation; 315 to 2,020 cps. Low noise level, 0.1 μ v (full scale) sensitivity, 60 db calibration.

attenuator. \$200.00 (cabinet), \$205.00 (rack mount).



416A Ratio Meter

Displays ratio between signals directly, irrespective of amplitude variations. Ideal with directional couplers and swept frequency sources for swept frequency measurements.

VSWR, reflection coefficient, gain, section loss and other microwave parameters. Calibrated in VSWR, % reflection, db. Oscilloscope, recorder output. \$475.00 (cabinet) \$460.00 (rack mount).

HEWLETT-PACKARD COMPANY

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DETECTING NOISE . . .

IN THE PRESENCE OF NOISE . . .

IN THE PRESENCE OF NOISE . . .

Radio Astronomy is the fundamental science which deals with the radio investigation of space. Each noise source provides its own contribution in the complex maze of microwave energy which surrounds us. A few decades ago, man added his own contribution in the form of communication transmitters, radars, and a vast host of radiators.

Radiometric systems calibrated directly in degrees Kelvin are the basic tools of a Radio Astronomer. A radiometer must be capable of sorting various noise sources available at its input and then amplifying the desired component.

Man-made receiving networks of the conventional variety introduce a considerable amount of internal noise, which is then further amplified. This noise is superimposed on the minute noise signals that are available at the antenna terminals; and hence the radiometer must not only select noise from noise at its input, but must identify the input noise signal in the presence of the normally high level of equipment noise.

Most cosmic noise signals are so weak that their total signal contribution represents only a small fraction of the noise power available at the radiometer output.

The state of the art recently established by Ewen Knight for the detection of broadband signals of noise-like character is $.01^{\circ}\text{K}$, which represents a sorting of noise from noise from noise with an effective detectability 56 db below the total noise level.

Reprints of technical papers describing some of these techniques are available upon request.

Personnel inquiries are welcome.

Ewen Knight CORPORATION
AT THE FRONTIERS OF *Electronics*

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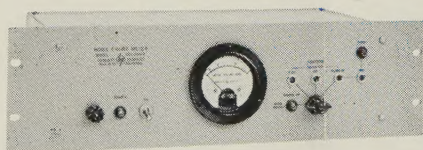
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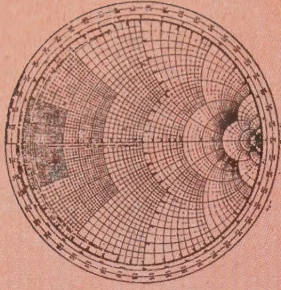
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A Hybrid Duplexer

Fundamental Considerations of Microwave Video
Diodes

Survey of Electronically Scanned Antennas, Part II

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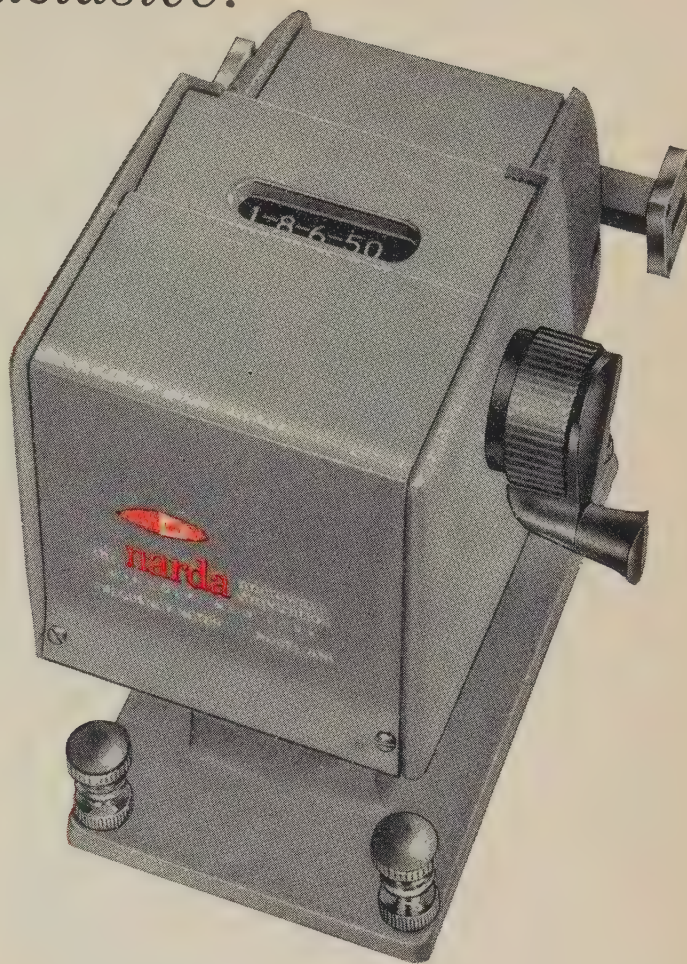
Direct- Reading Frequency Meters

No interpolations needed!

few — and only from Narda! Microwave frequency meters you can read at a glance! The digital counter permits even the least-experienced to get rapid, precise readings without interpolations, charts or curves. And, because the tuning rate is linear with frequency, the new meters are readily adaptable for remote indication. May be panel-mounted, too, if you have a system application.

Best of all, you get these features with no sacrifice of quality or accuracy (0.1% or better): The high-Q cavities are precision-bored; the cast housing is extremely rugged; the mechanism is carefully and accurately constructed. Electrically, the unit is equivalent to a straight section of waveguide when detuned. Dip at resonance is at least 10%. Complete specifications are shown at right.

This is just one of many precision Narda microwave products. For free copy of our complete catalog, write to: Dept. MJ-12.



SPECIFICATIONS

Band	X	KU	K
Frequency (KMC)	8.20-12.4	12.4-18.0	18.0-26.5
Waveguide (in.)	1 x 1/2	.702 x .391	1/2 x 1/4
Accuracy	0.08%	0.1%	0.1%
Loaded Q	7000	5000	4000
Length (in.)	4	4	4
NARDA Model Number	840	839	838
Price	\$195.	\$250.	\$275.



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118 160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650



A rose by any other name . . . etc., etc., etc. Shakespeare, we finally realized, was right. In the depths of the night quite recently, we recalled, with not a modicum of horror, those first disastrous days when we were trying to put a name to the corporation now known as Rantec. "It's gotta have 'micro' in it," an officer high on the echelon (there were three of us at the time) claimed, "without 'micro' we just ain't in the electronics business." "Well, we're not, really," some wretched iconoclast put forth, "has anybody seen a contract around here yet?"

Having gotten rid of him, we settled down to facts, or some semblance thereof. R for radomes, ANT for antennas, EC for electronic components. RANTEC. Fabulous. Meaningful. Easy to say with your mouth full. And it was truly valid for about three and a half days. Although we still make antennas (and quite a number, if the truth be known), Rantec is now involved up to its neck in ferrite devices, multiplexers, waveguide components and microwave sub-systems. See what we mean.

The upshot of this entire thing has been a little game called "Pin the Tail on the Electronic Firm" which has succeeded in pulling our senior research engineers away from the ping pong table and our technicians away from the chessboard. The amazing thing is that the game has no prizes and nobody wins. Of course, nobody loses either which might or might not mean something. The rules are simple: name a fictional electronic firm. Although, as we said, there are no prizes, no one can deny us the right of picking our favorites. Try these on for size. (1) HydroPeptic, manufacturers of irrigation equipment; (2) Macroneurotic and its wholly-owned subsidiary. Frustronics, which provide problems instead of solutions; and (3) Myoptics, Inc. which designs and develops complete systems with equally complete obsolescence.

If first prize there were to be, it must be awarded to one of our brilliant electronic engineers who thought it might be wise to open up a second-hand hardware company in Culver City, California, and call it the Used Tool Company.

Any engineer on the outside who might have a smattering of knowledge about microwave theory or antennas or electronics of various orders and who might or might not want a job can join in the fun. Send your answer to Rantec Corporation, Calabasas, California. Rantec. That's pretty funny, right there.

Speaking of filters, Rantec is way up front. Men who know filters best in such projects as Mercury, Titan, Polaris and Discoverer—choose Rantec two to one. Why? Strictly the result of Rantec's superb miracle blend of research and development.

Broadband Harmonic Filters from C through K, bands rejecting the second and third harmonics of any frequency in the pass-band region . . . Waveguide Band-Pass Filters employing from one to fifteen cavities with precise equal-ripple, maximally flat insertion loss or maximally flat time-delay response . . . Coupled Coaxial Resonator and

Coaxial Low-Pass, High-Pass and Band-Pass Filters in frequency ranges from 100mc to 10,000mc

Stripline Diplexing Filters to meet specific customer specifications for packaging, frequency band, response, isolation and power rating.

Below . . . the FS 203 Band-Pass Filter—pass-band

2,000-4,000mc; stop-bands 0-1,800mc;

4,400-12,000mc; VSWR in pass-band 1.5 max.;

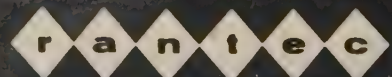
insertion loss 1db max. in pass-band, 50db

min. in stop-bands; impedance 50 ohms.

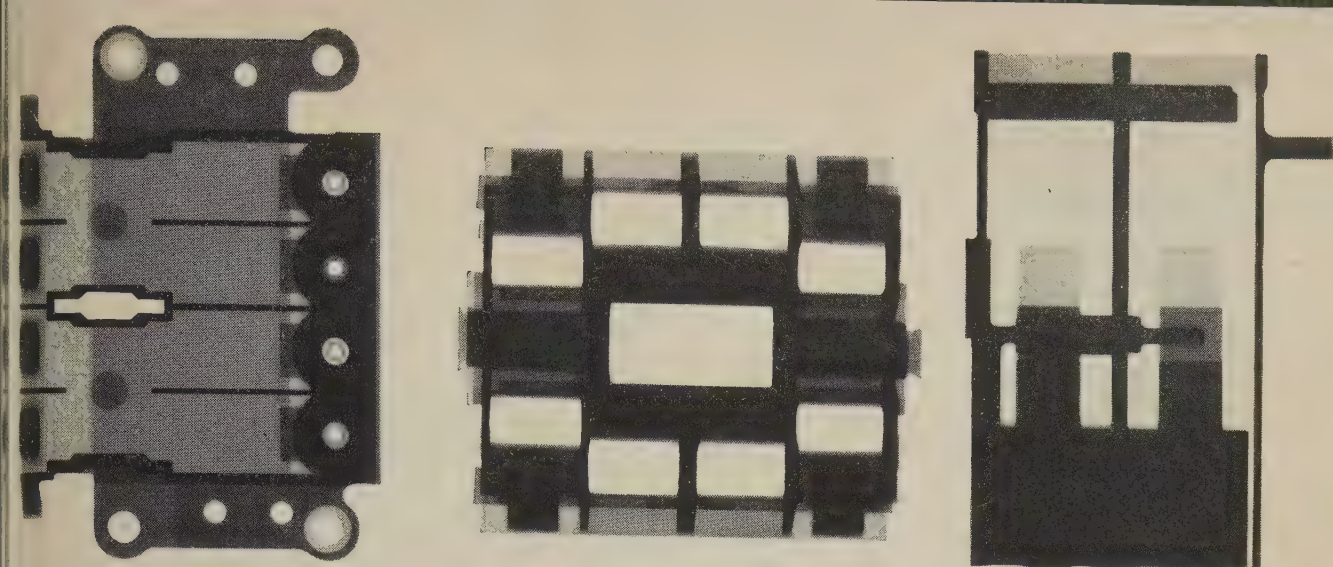
Reach for a Rantec . . . available in crush proof and soft pack! Also from Rantec . . . antennas,

ferrite devices, waveguide components, electric components and microwave sub-systems.

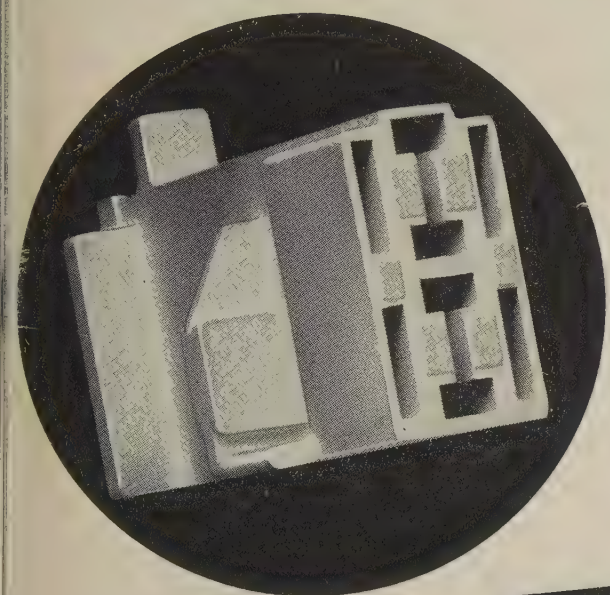
*it's
what's
up front
that
counts*



Rantec Corporation • Calabasas, California



THESE INSIDE PICTURES TELL THE STORY!



GORHAM ELECTRONICS foundry versatility delivers microwave castings fastest, at lowest cost

This is versatility that means *more* than just a complete and proven foundry capability. Much more! It means you can bring assignments to Gorham Electronics that are in the earliest embryonic idea stage. Gorham Electronics tackles these problems as an integrated service team. A team that includes in-depth brainpower and facilities in foundry metallurgy and in microwave design, research, engineering test and production... all in tune with up-to-the-minute electronics industry problems.

In addition to getting right answers *fast*, you'll get delivery when promised (often sooner), quality that doesn't compromise specs be they military or commercial, and costs that reflect a foundry plant that's organized and equipped on a par with the most modern in the world.

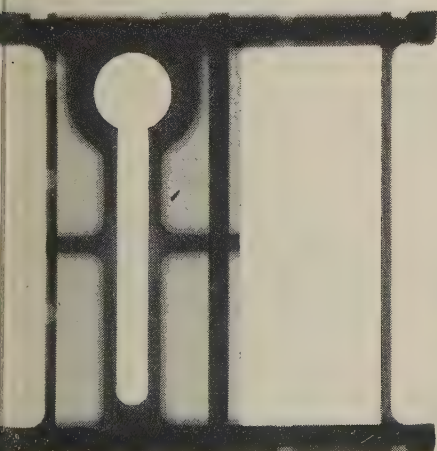
If it's results that you seek — it makes sense for you to call on



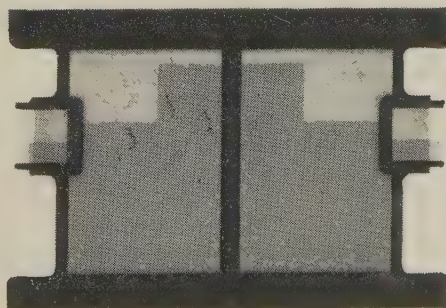
This illustrated brochure tells the complete Gorham Electronics story. Write for your copy!

Gorham
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DIVISION OF GORHAM MFG. CO.
PROVIDENCE 7, RHODE ISLAND



X-Ray photographs of air-borne radar component castings by Gorham Electronics for Raytheon Company.



Circle Reader Service Card 3

MICROVIEWS

OF THE MONTH

67 ► SURVEY OF ELECTRONICALLY SCANNED ANTENNAS — Part I Harold Shnitkin

This paper demonstrates the advantages of electronic scanning, discusses the phasing requirements for an electronically scanning aperture and explains design problems peculiar to such apertures. A number of schemes for satisfactory electronic scanning are presented. Included are discussions of frequency scanning, phase scanning with details of a variety of phase shifters, several multiple beam and beam switching techniques, scanning by amplitude modulation, reflector polarization scanning, and a frequency conversion phasing scheme.

73 ► EFFECTS OF EXTERNAL NOISE ON RADAR PERFORMANCE Robert L. Forward and Frances Richey

The rapid development of low-noise maser and parametric amplifiers have made it imperative for the radar systems engineer to be able to estimate the improvement in system performance that such low-noise receivers can make possible. This paper discusses the calculation of a minimum detectable signal, equivalent antenna temperature, discrete and continuous sources of external noise, the evaluation of the effects of lowering receiver noise, and an estimation of antenna noise for two specific systems applications: a ground-based satellite tracking station, and a high-altitude airborne search radar. Although the benefits to be achieved from using a low-noise receiver depend on the particular systems application, as shown in the examples, in general one may say that improvement in system range can be obtained by lowering the receiver noise temperature, provided the receiver noise temperature is not already less than 10 to 20 percent of the external noise temperature.

81 ► ELECTROSTATIC FOCUSING OF MICROWAVE TUBES — Part II J. R. Hechtel

Periodic electrostatic focusing systems are discussed. Results obtained with such systems, including backward-wave oscillators and medium power traveling wave tubes are reviewed.

87 ► CONTROL OF THE AMPLITUDE AND PHASE OF AN ELECTROMAGNETIC WAVE IN A WAVEGUIDE BY MEANS OF A GERMANIUM PLATE

N. V. Aleksandrov, L. B. Gorskaya, E. M. Gershenson, and V. S. Etkin

It is shown that the amplitude and phase of an electromagnetic wave in a waveguide can be controlled by means of a germanium plate, located transverse to the waveguide and placed in the magnetic field, by passing through this plate the control current.

OUR COVER

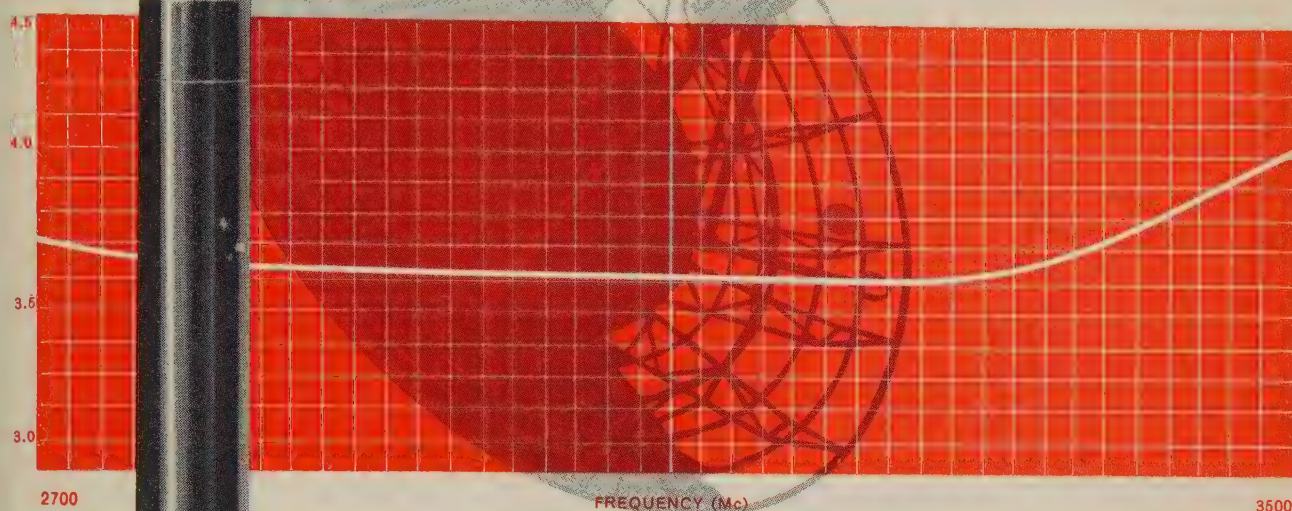
The cover illustration shows an assembled panel of the multidirectional beam antenna belonging to the Air Height Surveillance Radar, presently under construction at The W. L. Maxson Corporation for the Federal Aviation Agency. It generates 111 fanned antenna beams, approximately 0.3 degrees wide, by utilizing a network of 140,000 directional couplers and 33 miles of S-band waveguide. See page 67.

the
microwave
journal



From RCA's microwave designers

New Ultra-Low-Noise S-Band Traveling-Wave Tubes



With a Terminal Noise Figure as Low as 2.8 db.

Here are the dramatic facts about the new RCA developmental type A-1207 series of Ultra-Low-Noise Traveling-Wave Tubes.

4.5 db Maximum Terminal Noise Figure. This is a realistic value of noise figure because it includes coupler losses. Because this is a maximum value, the average noise figure for tubes in this series is considerably less than 4.5 db. Laboratory tests of tubes of this series have shown terminal noise-figure values as low as 2.8 db.

Advanced Proven Design. The design of the developmental type A-1207 series is based on that of the well known RCA-6861. Only recently Zurich Airport reported 19,200 hours of service from a 6861.

Complete S-Band Coverage. The developmental type A-1207 series offers coverage in bandwidths of 200 Mc to 800 Mc for S-band frequencies between 2200 Mc and 4100 Mc.

1 Milliwatt Minimum Power Output. You'll obtain an output of over 1 milliwatt with a minimum gain of 20 db from any tube in this remarkable series.

Most important of all, the RCA developmental type A-1207 series is a firm design, ready for immediate production and delivery to meet your schedules. Get full details about this unusual new line of ultra-low-noise traveling-wave tubes today. Contact the RCA Field Office nearest you. RCA Electron Tube Division, Harrison, N. J.

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OLD TIMERS

Years ago (we have been told) a microwave engineer was experienced in all areas of microwave design. Today the typical microwave engineer is most often a specialist concentrating on one narrow portion of the microwave field.

This is not to imply that today's microwave engineer could not perform as well as some of the old timers. Actually, the new engineers should be better equipped than the old timers, otherwise there would be something wrong with the progress of our educational system.

When the microwave field got its first real concentrated push, there was no Rad Lab Series, no RRL volumes, no IRE transactions and no shelf of books covering each and every phase of microwaves.

There were reports, of course, and there were meetings. There was ingenuity and there was urgency. So the old time microwave man learned the hard way, by designing, building and testing, by trying and failing and then trying again, time after time.

There were no well-documented catalogues, brochures, trade magazines and, of course, no *microwave journal*.

The microwave engineer had to be familiar with all of the plumbing, not just isolated components. It was easier to do then because the components were less complicated and there were far fewer in a given system than in the equivalent system today.

The technical problems that occupied the interest then were quite different from the problems encountered today. Typical problems the early microwave engineer dealt with might include such items as how to connect one waveguide to another—and then someone invented choke and flange coupling; or should an adjustable length of line be used between the TR box and the magnetron or would the magnetrons be sufficiently uniform to eliminate the necessity—and then someone invented the ATR tube; or the question of whether to put in a number of tuning screws or to rely on dent tuning the final assembly.

These problems and hundreds more just like them were of major concern.

Today our problems are far more sophisticated, far more complicated. Sometimes in our intense pre-occupation with our work we forget that the solutions to those early problems are today's building blocks just as the solutions to today's problems will become tomorrow's building blocks.

Some of the old timers are still around, for it has often been demonstrated that microwave men do not always fade away; they very often get promoted into administrative positions.

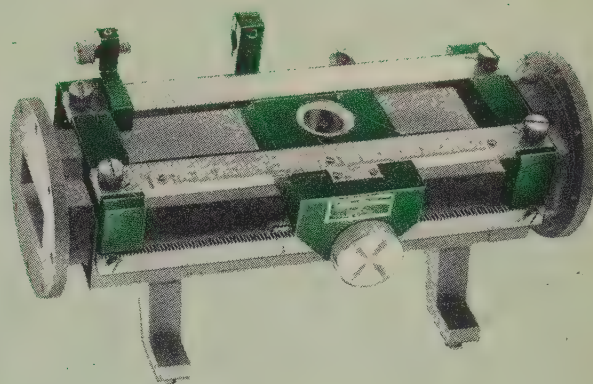
Some of the old timers are still doing engineering work, making major contributions. Others have gone into other fields of endeavor.

To all of them, the pioneers of our industry, we tip our hats in respect.

Ted Saad

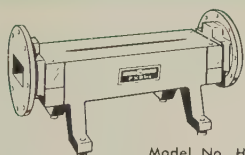
Interchangeable SLOTTED SECTIONS

convenient and positive

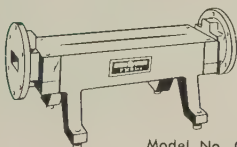


conveniently interchangeable waveguide sections
no slope adjustment required
vernier position scale readable to 0.1 mm.
dial gauge holder and movable stop
tapered slots to minimize residual VSWR

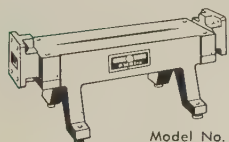
INTERCHANGEABLE WAVEGUIDE SECTIONS



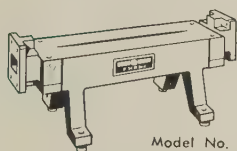
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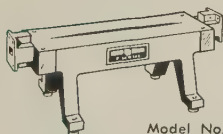
Model No. C115A



Model No. W115A

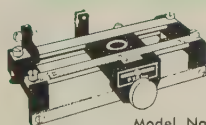


Model No. X115A



Model No. Y115A

UNIVERSAL CARRIAGE



Model No. Z116A

Like the finest camera with a precisely fitted set of lenses, the FXR Universal Carriage and family of five Interchangeable Slotted Sections are matched to perfection. "Togetherness" with this unrivalled modular waveguide system gains new meaning . . . more rapid interchange of each section without tools or need for alignment, and more dependable performance over the entire frequency range from 3.95 kmc to 18.00 kmc. Another fine FXR "package" with quality and reliability built into it—from the first mark on the drawing board.

SERIES 115 PRECISION SLOTTED SECTIONS

MODEL NO.	FREQUENCY RANGE (KMC)	WAVEGUIDE DIMENSIONS (Inches)	INSERTION LENGTH	WAVEGUIDE TYPE	FLANGE TYPE
H115A	3.95- 5.85	2 x 1	10 $\frac{3}{8}$ in.	RG-49/U	UG-149A/U
C115A	5.85- 8.20	1 $\frac{1}{2}$ x $\frac{3}{4}$	10 $\frac{3}{8}$ in.	RG-50/U	UG-344/U
W115A	7.05-10.00	1 $\frac{1}{4}$ x $\frac{5}{8}$	10 $\frac{3}{8}$ in.	RG-51/U	UG-51/U
X115A	8.20-12.40	1 x $\frac{1}{2}$	10 $\frac{3}{8}$ in.	RG-52/U	UG-39/U
Y115A	12.40-18.00	0.622 x 0.311 ID	10 $\frac{3}{8}$ in.	RG-91/U	UG-419/U

ACCESSORY: FXR Model No. B200A Tunable Probe.
All units when mounted in Z116A Carriage:
Slope—1.01 max. Irregularity—1.005 max.

Write for Bulletin No. SS115 or contact your local FXR representative.



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The Mesh Cathode

AN ITT BREAKTHROUGH IN RADAR SWITCH TUBE DESIGN

This seemingly delicate web of wire is actually the most rugged and structurally stable construction ever developed for power tube cathodes. Consisting of a fine cylindrical mesh instead of the usual filament configuration, the exclusive ITT mesh cathode is now available in a number of high-performance pulse triodes and power diodes. The triodes are specifically designed for radar switching applications; the diodes are ideally suited for rectifier, clipper and charging service.

Mesh cathode construction, in addition to its mechanical advantages, offers improved emission per watt in comparison with conventional cathodes, as well as quick heating and superior temperature stabilization. The cylindrical design results in an emission pattern that uses more of the available grid surface and thus reduces grid emission problems. This latest ITT power tube "first" is probably the closest existing approximation of a theoretically ideal "physicist's cathode."

Write for information on the complete line of ITT pulsed modulator triodes and power diodes. Application assistance is available for your specific requirements.



MODULATOR TRIODES - PULSED OPERATION				
TYPE	PULSE POWER OUTPUT 1 (kw)	D-C PLATE VOLTAGE (kv)	PULSE CURRENT 1 (amperes)	PULSE CURRENT 2 (amperes)
F-7206	2200	18	220	350
F-7328	900	20	100	160
F-7839	7800	65	160	230
D-1037	30000	65	650	1000
F-6920	4100	35	140	200
F-7012	90	18	40	65

1 At rated filament voltage
2 At elevated filament voltage

HIGH VACUUM POWER DIODES				
TYPE	APPLICATION	PEAK INVERSE VOLTAGE (kv)	PEAK CURRENT (amperes)	AVERAGE CURRENT (amperes)
D-1033	Rectifier	60	36	12
	Shunt or Charging	60	150	—
D-1034	Rectifier	50	45	15
	Shunt or Charging	50	200	—
D-1038	Rectifier	40	18	6
	Shunt or Charging	40	100	—
D-1039	Rectifier	65	21	7
	Shunt or Charging	65	100	—

ELECTRON TUBE DEPARTMENT ■ COMPONENTS DIVISION
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, CLIFTON, NEW JERSEY

ITT COMPONENTS DIVISION PRODUCTS: POWER TRIODES AND DIODES • IATRON STORAGE TUBES • HYDROGEN THYRATONS • TRAVELING WAVE TUBES • SELENIUM RECTIFIERS • SILICON DIODES AND RECTIFIERS • TANTALUM CAPACITORS

Circle Reader Service Card 6

URSI in London, 1960

"THE PORTERS WITH THEIR PURPLE HATS
... A BEVY OF RUSSIANS
... A VISIT TO JODRELL BANK"



ROBERT C. HANSEN

ASSOCIATE EDITOR
the microwave journal

To many engineers URSI may seem a strange collection of letters, especially when explained as the International Scientific Radio Union which is clearly ISRU! However, these are one and the same, as the initials arose from the French version of the name, Union Radio Scientifique Internationale. This editorial is occasioned by the fact that I recently had the pleasure of attending the thirteenth triennial General Assembly in London September 5-15, as one of a number of USA delegates. Before explaining the nature of the London meeting, let us shed some light on URSI itself and upon how URSI originated.

As is the case with many organizations, the tale of URSI is inseparably intertwined with that of an individual, Dr. Robert Goldschmidt, one of the founders and the chief sparkplug of URSI for 22 years. Goldschmidt, born in 1877 in Brussels, was a brilliant inventor and scientist who established a radio laboratory in 1900. Between 1900 and 1910 he carried out experiments in radio propagation which led to a series of radio stations connecting various parts of the Belgian Congo. Goldschmidt, like many creative scientists, did not limit his attention to electricity, having to his credit the design of a hydro-glider, the first Belgian dirigible, and a wood-burning steam locomotive for the Belgian Congo.

Since radio waves made long distance communication possible, scientists of several countries were involved in the study and application of radio propagation and phenomenon. In fact, the first radio link in 1901 involved Italy and England in Europe, and Canada and USA in North America! So it was natural that an international radio society should be formed. Goldschmidt, Ferrié, and Abraham of France; Vanni of Italy; and Duddell of England organized such a society in 1913. In 1921 the name International Scientific Radio Union was chosen, and URSI was formally recognized by ICSU, the International Council of Scientific Unions. Goldschmidt was General Secretary of URSI from the start until his death in 1935. The present General Secretary, Colonel Herbays, is a Belgian, and the Union's accounts are carried in francs.

Aims of URSI are to aid and organize radio research involving world-wide cooperation, to determine common methods for radio measurements and standards, and to encourage the scientific investigation of radio communications. Radio is a field especially suited for world-wide cooperative research programs. Some aspects such as radio

astronomy and space communications transcend even the earth's boundary. URSI, through its meetings and committee activities, furnishes a valuable meeting ground wherein those working in the radio field can exchange ideas and arrange cooperative programs. International scientific cooperation is being achieved quietly and without fanfare, an encouraging sign in these times of world tensions and crises.

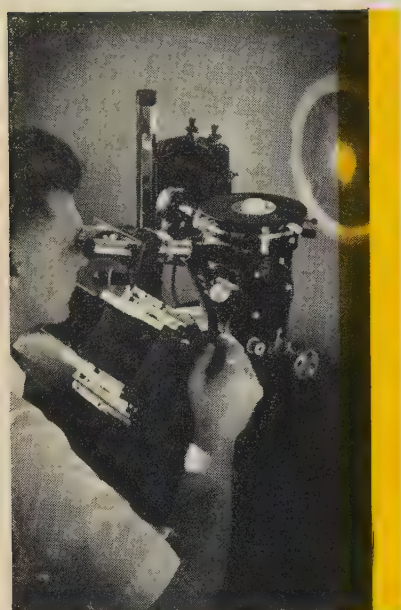
To meet its objectives, URSI is organized into seven permanent bodies called "Commissions," for centralizing studies in the principal technical areas. Of these seven commissions, the first several deal with standards, propagation, and noise, and have been active since the inception of URSI. Others have been added as their need became apparent; for example, Commission V on radio astronomy was established in 1948. The commissions and recently-elected chairmen are as follows:

- Commission I Radio Measurements and Standards — Prof. Adelsberger (Germany)
- II Tropospheric Propagation — J. Voge (France)
- III Ionospheric Propagation — J. A. Ratcliffe (England)
- IV Radio Noise of Terrestrial Origin — R. A. Helliwell (USA)
- V Radio Astronomy — Prof. Lovell (England)
- VI Radio Waves and Circuits — J. Loeb (France)
- VII Radio Electronics — W. G. Shepherd (USA)

Except for the last two, these titles are fairly clear. Radio Waves and Circuits includes antennas, circuit theory, and information theory, while Radio Electronics covers tubes, ferrites, solid state devices, and plasmas. The intent has been to cover all phases of radio communications.

One other international organization needs to be mentioned: the CCIR, or International Radio Consultative Committee (here again the initials are derived from the

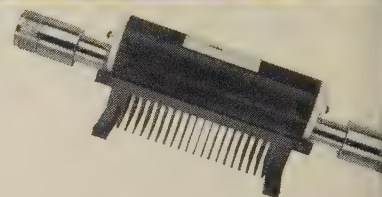
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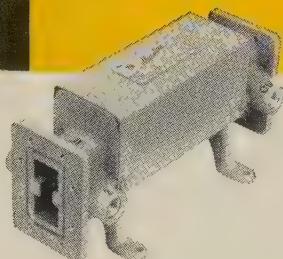
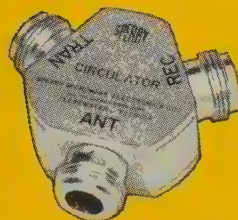
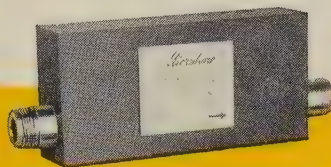
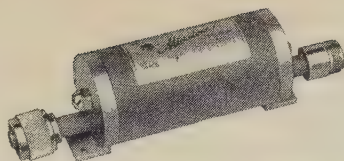
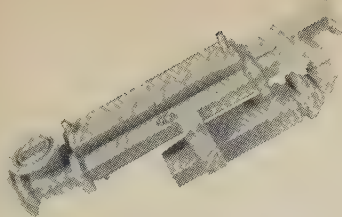
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MATERIALS**



Materials capability assures superiority

Eight years of intensive research and development on solid state microwave devices, utilizing its fully-equipped ferrite materials laboratory, enable Sperry Microwave Electronics Company to offer the most advanced devices and materials yet developed by the industry.

Yttrium and yttrium gadolinium garnet standard bars are now available for early delivery. These advanced materials, with their consistent composition and characteristics, make possible more advanced solid state devices than were heretofore available.



SPERRY

solid state devices

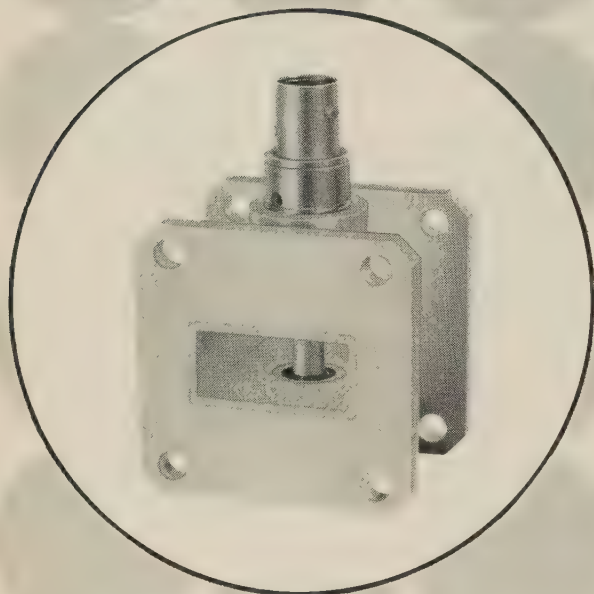
Miniaturized internal magnet coaxial isolators, miniaturized strip transmission line isolators, miniaturized circulators, high- and low-power octave bandwidth coaxial and ridge waveguide isolators, and specialized devices are available from stock.

Isolators, attenuators, equalizers, limiters, filters, harmonic suppressors, duplexers, circulators, switches and polarizers have been developed for optimum performance where used as system components. The frequency range covered is from 250 to 12,000 mc.

Send for specific information and recommendations for any development or production application.

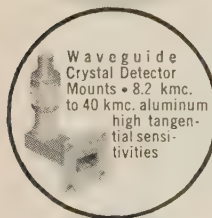
SPERRY MICROWAVE ELECTRONICS COMPANY, CLEARWATER, FLORIDA
DIVISION OF SPERRY RAND CORPORATION

NOW! BROADBAND WAVEGUIDE SOLID STATE CRYSTAL SWITCHES



Currently in production are broadband units operating from 8.2 to 10.0 KMC, with other ranges under development. Typical characteristics over most of the band are insertion loss of less than 1.5 db and isolation greater than 36 db. Higher isolation and lower insertion losses can be obtained through special design over restricted ranges on order.

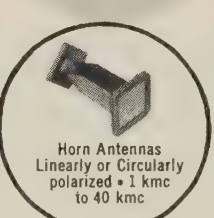
AEL Crystal switches in waveguide or coax feature switching rates faster than 10 milli-microseconds, low driving power and reliability and are particularly applicable where high speed, inertialess RF switching is required with small power drain.



Waveguide
Crystal Detector
Mounts • 8.2 kmc.
to 40 kmc. aluminum
high tangen-
tial sensi-
tivities



Coaxial crystal detector
mounts • 50 mc
to 12 kmc



Horn Antennas
Linearly or Circularly
polarized • 1 kmc
to 40 kmc

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Investigate the opportunities at AEL for creative engineers

In Canada contact: Conway Electronic Enterprises Regd., Toronto, Canada

HANSEN

(Continued from page 11)

French version of the name). CCIR is an organization more concerned with the details of international radio communications such as interference and frequency allocations. URSI, on the other hand, is primarily interested in the scientific aspects of radio, and makes recommendations to CCIR when appropriate. A good analogy is that CCIR is the world version of FCC, while URSI is similar to IRE in the radio field.

Unlike the IRE however, membership in URSI is not open to individuals but is limited to nations. There are six categories of membership, with the cost and number of votes different in each category, so that each nation may choose a membership category commensurate with its activities in radio. If the categories are represented by $n=1(1)6$, then the n^{th} category carries n votes at a cost of 2^{n-1} units where unit cost is set by the General Assembly, and is now \$125 per year. USA is a category six member. With the admission of Peru at London, the member nations are 27: Australia, Austria, Belgium, Canada, Czechoslovakia, Denmark, Finland, France, Germany, Federal Republic, Greece, India, Italy, Japan, Morocco, Netherlands, New Zealand, Peru, Poland, Portugal, Spain, Sweden, Switzerland, Union of South Africa, United Kingdom, United States, U.S.S.R., and Yugoslavia.

Officers of URSI are Professor Smith-Rose (England) President; four Vice-Presidents, Koga (Japan), Woonton (Canada), Decaux (France), Prokhorov (USSR); Secretary General Herbays; Treasurer Manneback (Belgium) plus the seven Commission Chairmen already mentioned. Each of these serves a three-year term which coincides with the three-year period between the Assemblies. These Assemblies are held in the various member countries in rotation, with the USA hosting in 1926 and 1957; the latter Assembly was held at Boulder, Colorado.

At London the General Assembly was opened by a plenary assembly and a flag raising. On following days each commission held a business meeting plus a number of technical sessions, with as many as five simultaneous sessions occurring. University College of the University of London was the locale. Although the official languages of URSI are English and French, most papers were delivered in English. Most of the papers presented at these technical sessions were either summary reports of progress or reports on a new development in the field. Ample time was allotted during the sessions for general discussion, and in some cases the 'workshop' type discussion were more stimulating and edifying than the papers. About 450 delegates attended the Assembly, with many wives in tow. Elsevier publishing house of Netherlands will publish a volume for each Commission including the papers presented and the discussion following.

Some fleeting vignettes from the London General Assembly are the University College porters with their purple hats and long coats; Lloyd Berkner giving the first Goldschmidt URSI Memorial Lecture on Science in Space to the heterogeneous collection of delegates, including a bevy of Russians; and a visit to Jodrell Bank. Some memoranda

ble city sights: Piccadilly Circus, excellent London subways, windbags at Hyde Park, tall red buses, throngs of people, statues, ancient churches and castles.

Another phase of the General Assembly concerns the national committee reports. Each national committee prepares for the Assembly a report detailing the progress made in its own country during the three-year interval. The USA report is a voluminous document containing many authoritative review papers, e.g., Elias on coding, Price on detection theory, Zadeh on prediction and filtering, Weinberg on circuit theory, Felsen and Siegel and Twersky on scattering, Bickmore and Hansen on antennas, Zucker on surface and leaky wave antennas, Tien and Heffner on parametric amplifiers, Tien and Lax on ferrites, Siegman on masers, Smullin on microwave tubes and plasmas, to mention only those in Commissions VI and VII. The entire USA report including these has been published in the Journal of Research of the NBS, Part D, November-December 1960. URSI will also publish a document(s) containing the national committee reports, but the NBS journal is more readily available. The USA report will serve a useful function not only to URSI but to all those interested in microwaves, antennas, propagation, etc., as the PGMTT Transactions no longer publish an annual review of USA work. Review articles are very useful since no one can read all the pertinent journals these days; the review gives one a quick start on a subject.

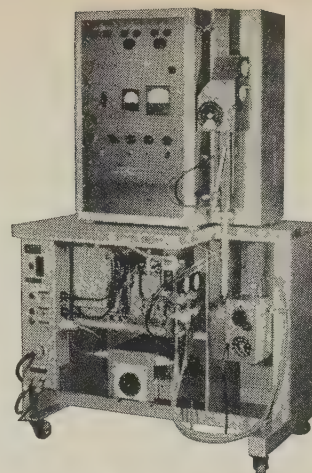
Another URSI service is the daily Ursigram, which started with transmissions from the Eiffel Tower in 1928, and is still in operation with, of course, newer equipment. A special 5-digit code is broadcast, carrying information on the ionospheric critical frequency, solar flares, sunspots, and cosmic ray data. This material is used by many organizations for predicting propagation.

An additional URSI function is sponsoring the series of international electromagnetic theory symposia. This started with the McGill University Symposium in 1952 at Montreal which was so successful that another was held at the University of Michigan in 1955. Some may remember that the Proceedings of the 1955 Symposium were printed in a short run which was quickly exhausted; copies are still very scarce. In 1959 the third was held at the University of Toronto. All of these included such technical areas as scattering and diffraction, surface and leaky waves, variational methods, and propagation in non-homogeneous and anisotropic media. Plans are under way to hold the next EM Theory Symposium in Copenhagen in 1962, so it's time to start a research project which will be ready for reporting in 1962!

All these functions transpire at the international level. Most of the work of URSI takes place in the countries themselves. The USA organization is perhaps typical of that of the larger countries. Each Commission has a Chairman, Vice-Chairman, and Secretary and a list of Commission members, all in the USA. These are responsible for organizing domestic symposia, coordinating research goals, and supporting the work of the General Assembly. USA Commission members are elected by each of the Commissions. The USA Commission Chairmen are as follows:

(Continued on page 16)

December, 1960



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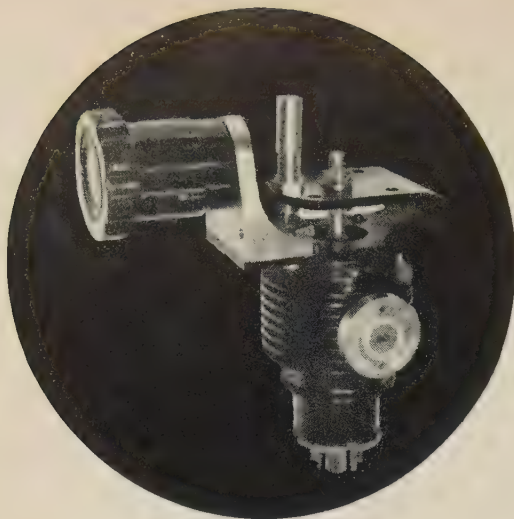
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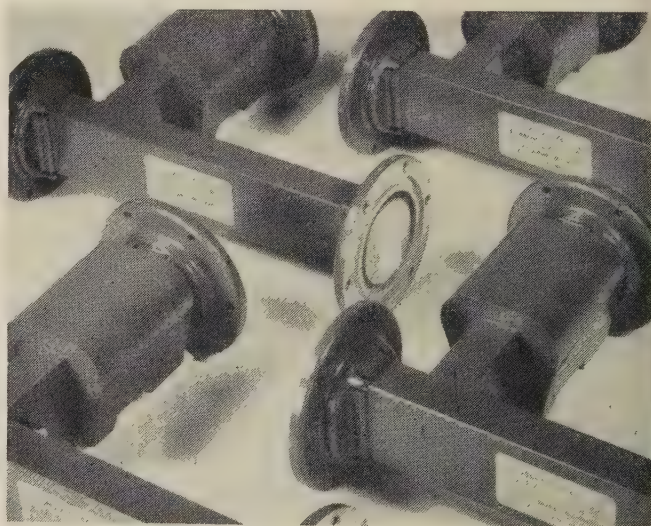
(Continued from page 15)

- | | |
|---------------------|---------------------|
| I R. W. Beatty | V E. F. McClain |
| II Irvin H. Gerks | VI John I. Bohnert |
| III L. A. Manning | VII Marvin Chodorow |
| IV William Crichlow | |

These, plus representatives of the IRE, Department of Commerce, FCC, DOD, Army, Navy, USAF, and National Research Council, with 12 additional members-at-large belong to the USA National Committee of URSI.

In the USA, the National Committee sponsors two meetings each year. The spring meeting is usually in Washington, D.C., at cherry blossom time, but the fall meeting moves about both spatially and temporally. This December it will be held in Boulder, Colorado (bring your skis). These meetings are informal with a program of papers, lots of time for discussions and bull sessions no printed record, and no show.

For those who would like to help with the work of URSI, the two yearly USA meetings are the vehicles. Each meeting requires lots of time and energy from volunteer workers: making arrangements, handling registration, assembling speakers and abstracts, operating slide projectors, and the 1001 other things that have to be done. Each meeting is announced by mail to all IRE, PGAP and PGMTT members well in advance. Write the chairman and ask how you can help, or write one of the USA Commission Chairmen. Even if you can't help, the most important thing is to attend the meetings which are the best forum for informal technical interchange.



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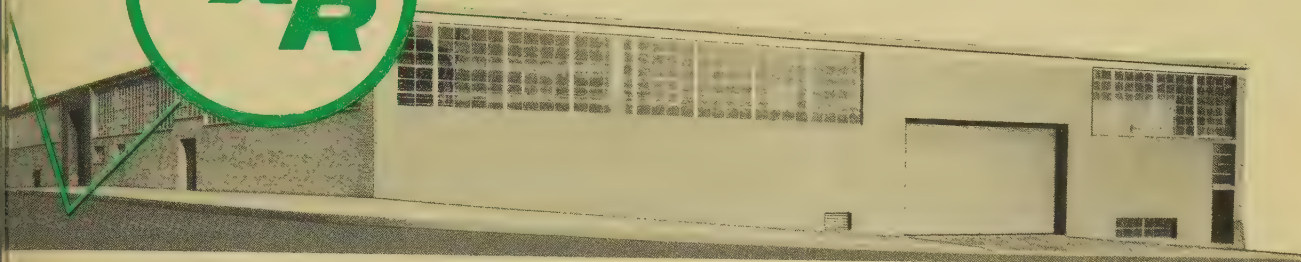
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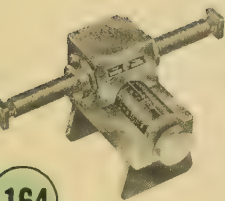
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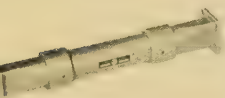
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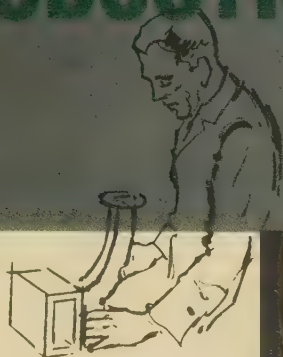
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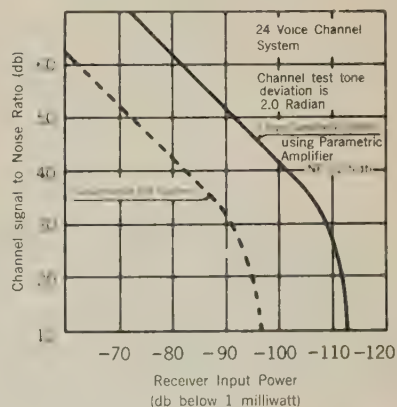
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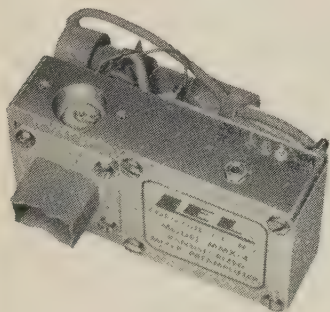
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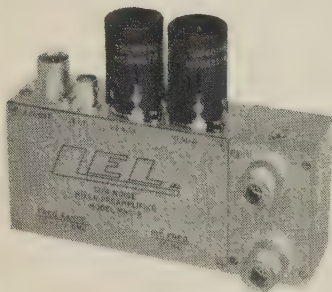
Noise Figure: 7.5db



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The MMX Series of Integrated Microwave Mixer-Preamplifiers.

Noise Figure: 7.5db



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The MML, MMS and MMC Series of Coaxial Mixer-Preamplifiers.

Noise Figure: 7.5db



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The MMK Series of Integrated Microwave Mixer-Preamplifiers.

Noise Figure: 10.0db

LEL stocks the most complete line of low noise microwave Mixer-Preamplifiers available ANYWHERE.

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Industry News

PRD APPOINTS MANAGER OF MANUFACTURING

Murray S. Dippel has been appointed manager of manufacturing at PRD Electronics, Inc., Brooklyn, N. Y., manufacturer of microwave and electronic instrumentation. PRD is a subsidiary of Harris-Intertype Corp., Cleveland, Ohio.

Dippel, 37, with PRD since 1957, was formerly manager of planning and has previously been associated with Kahn Industries as general manager and ACF Industries — Avion Division as production manager. He attended Cornell University and graduated from Newark College of Engineering in 1947 with a degree in Mechanical Engineering; his education was interrupted by four years in the U. S. Navy.

Henry H. Michaels, Jr., president of PRD, said that Dippel will be responsible for the manufacturing, purchasing, industrial engineering, and production control activities at PRD.

— m w j —

DR. POKORNY JOINS LITTON STAFF

Dr. Gerald E. Pokorny has joined the staff of Litton Industries Electron Tube Division, San Carlos, Cal., as a senior scientist in the Division's Research Laboratory. Dr. Joseph F. Hull, manager of the laboratory, said Dr. Pokorny will be primarily responsible for the basic research program of the Electron Tube Division.

For the last seven years, Dr. Pokorny has been section chief of the United States Army Signal Corps Microwave Research Section, Fort Monmouth, N. J. He also has been a research assistant on vacuum tubes and technology at the University of Technology, Vienna, Austria.

After receiving his MS degree in engineering physics in 1951, Dr. Pokorny earned his PhD in technical science (electronics) in 1953 at the University of Technology.

Dr. Pokorny is a member of the Institute of Radio Engineers, the Professional Group on Electron Devices, and the Professional Group on Microwave Theory and Technique.

— m w j —

AIRCRAFT ARMAMENTS AWARDED ASW CONTRACT

The U.S. Naval Training Device Center, Port Washington, N.Y., has announced the award of a contract to Aircraft Armaments, Inc., Cockeysville, Md., for the development, manufacture and installation of an anti-submarine warfare training facility at Pearl Harbor, Hawaii.

The entire project, which will include the design and development of optical and electronic simulators as well as display and digital computing equipment, will require two years of engineering, manufacture, installation, and checkout.

The contract amount is in excess of \$3,500,000.

— m w j —

POLARAD HOLDS ANNUAL STOCKHOLDERS MEETING

Polarad Electronics Corp., Long Island City, N. Y. will begin to market a wide variety of new products early in 1967. Dr. D. L. Jaffe, president, told stockholders at the firm's annual meeting. Company sponsored research and development work in connection with new products continues to be extensive, Dr. Jaffe said.

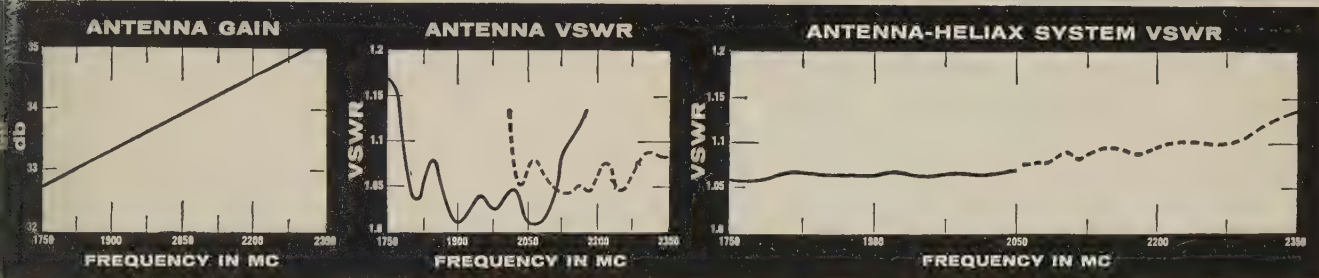
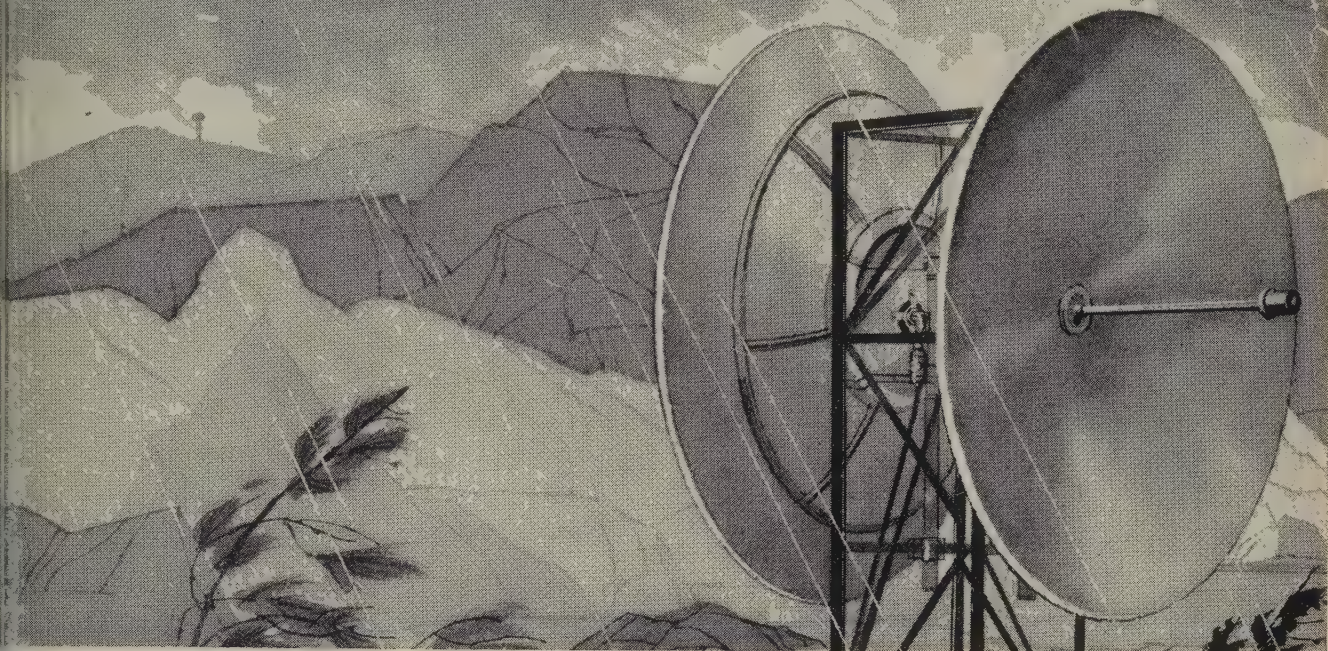
The forthcoming line of new products, which include more new instruments than ever before introduced during a single year, includes a new servo analyzer, and a transistorized line of spectrum analyzers, microwave receivers, and field intensity meters. In addition to new microwave instruments, new lines of scientific instruments for the fields of chemistry and biology are being added along with advanced types of ceramic klystron tubes.

— m w j —

(Continued on page 33)

the microwave journal

NO MARGIN FOR ERROR...



Antenna performance based on 60% gain factor

High and low band antenna VSWR plots of production test samples

Test results of high and low band production antennas and 110 feet of 7/8 inch HELIAX cable

A 600-channel microwave system to carry vital defence data was recently developed by Canadian-Marconi Company for the Royal Canadian Air Force. Because of its strategic value, this long haul line-of-sight system demanded reliable performance in the antenna equipment.

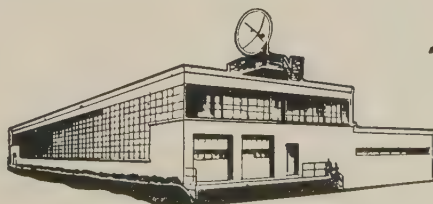
ANDREW Antenna Corporation, Ltd. is proud to have been chosen to design and produce this equipment to meet specific system requirements.

ANDREW microwave antenna, Type 21362, designed for this 1790-2260 mc system guaranteed a vswr under 1.1. Minimum antenna gain of 33 db resulted from production models having gain factors of better than 60%. The antenna characteristics were sustained in the system through the use of ANDREW HELIAX, the flexible air dielectric cable. HELIAX was chosen for its low vswr and attenuation, ease of handling and mechanical stability.

Automatic pressurizing equipment to regulate the dry air supply for this RF system was provided with an ANDREW Type 1910 dehydrator.

This is just one of many ANDREW antenna system installations in Canada that are consistently giving optimum performance in UHF/VHF and microwave frequencies. To get all the facts on ANDREW antenna systems, write or call today, giving your specific requirements.

We are anxious to supply U.S. Defence Contractors with Andrew antenna and transmission line items from Canada. Such purchases are duty-free, under the new, production sharing program.

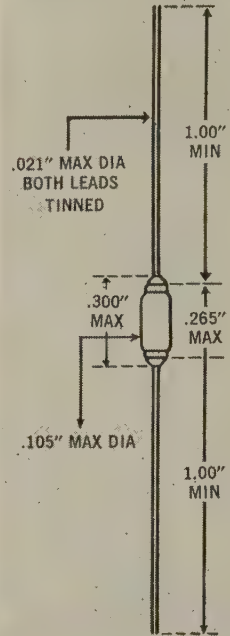
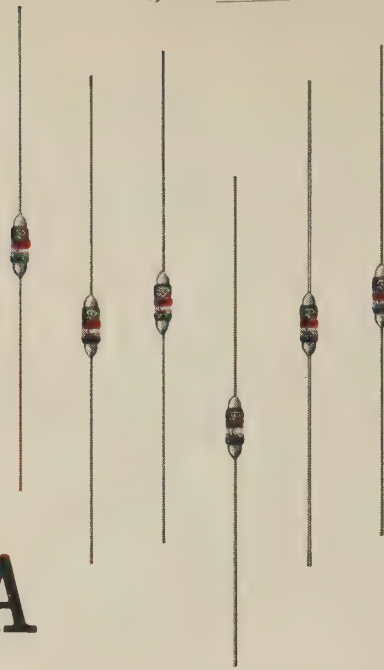


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90%
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SYLVANIA MICRO-MIN DIODES

offer microminiaturization
in microwave circuitry

One-tenth the size, one-tenth the weight—90% smaller than their prototypes—Sylvania Micro-Min Diodes extend design possibilities where microminiaturization and reliability are essential to microwave equipment.

Sylvania Micro-Min mixer and detector diodes feature true hermetic seals... withstand temperatures of -55°C to $+150^{\circ}\text{C}$... meet MIL-S-19500B environmental specs for shock, vibration, lead fatigue, acceleration, moisture resistance, soldering and temperature cycling.

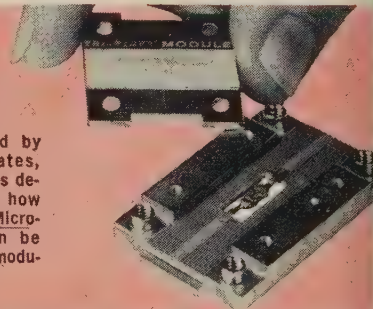
New packages—even smaller than Micro-Min Diodes—are now under development at Sylvania! Our engineers can work with you in developing new microminiaturized equipment. Contact them.

If your present design requirements are for exceptionally small size, extremely lightweight and maximum reliability, specify Sylvania Microwave Micro-Min Diodes. For price and delivery information, contact your Sylvania Field Office or your local franchised Sylvania Semiconductor Distributor. For technical data on specific Sylvania Micro-Min Diodes, write Semiconductor Division, Sylvania Electric Products Inc., Dept. 3512, Woburn, Massachusetts.

MICRO-MIN TYPE	APPLICATION	PROTOTYPE
1N830	UHF Detector	—
1N830A	UHF Detector	—
1N831*	S Band Mixer	1N21C*
1N831A*	S Band Mixer	1N21E*
1N832*	X Band Mixer	1N23C*
1N833	X Band Video Detector	1N358
1N918	Ku Band Mixer	1N78

*Available in Matched Pairs

Photo shows Sylvania Micro-Min Diode as used in TRI-PLATE® detector module designed by Sanders Associates, Nashua, N. H. This device illustrates how easily Sylvania Micro-Min Diodes can be integrated into a modular construction.



Sylvania Micro-Min Diodes also are available with gold-plated ribbon leads.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**



the microwave journal

DAVID PACKARD

PRESIDENT,

Hewlett-Packard Company

PALO ALTO, CALIFORNIA

By

ADELAIDE PAINE

The sheer glass walls of his company's new plant are as unorthodox as are many of the methods which have led David Packard to the top of the hill in the electronic industry. From the garage workshop where he and his partner William R. Hewlett built their first nine audio oscillators for Walt Disney, they have progressed to the top of the hill at the Stanford Industrial Park in Palo Alto where they now manufacture a diversified line of 400 electronic test and measurement instruments.

David Packard himself is a man large in physical stature as well as professional stature with an appearance of great strength and determination balanced by a quiet, warm sense of humor. This was much in evidence when he mentioned the big-game hunting safaris he and some of his employees have taken to deepest Nevada by jeep and station wagon.

At the moment, besides serving as president of Hewlett-Packard, he is also director of eight other corporations and institutions, all calling for varying degrees of his available time. One that he finds most interesting is that of serving as vice-president of the board of trustees of Stanford University. He particularly enjoys this because he has so many ties with the university which was his alma mater, whose industrial lands now house his company's headquarters, and whose faculty members number among his many close friends.

David Packard was born in Pueblo, Colorado, a steel town on the eastern flank of the Rockies. He had decided early in his teens that he wanted to be in electronics, but as Pueblo had little to offer him as an aspiring engineer, he left to attend Stanford University. It was during high school that his interest in science was kindled through amateur radio, the catalyst for many men in engineering. He built his own rig and was an active ham throughout his early college days. This hobby stood him in good stead, for he worked at radio repair during his college years.

He met his partner, William Hewlett, during his last years at Stanford, and, as he says, they sat around even when and discussed going into business for themselves when they graduated. David Packard insists that at that point they were more or less talking to keep up their morale, for outside the walls of their college, depression still gripped the nation and the green pastures of engineering



were only dust bowls offering little succor to graduating engineers.

On graduation from Stanford he went back to his home state and attended the University of Colorado for a year. Then in 1935 he was hired by General Electric and was sent to work in their vacuum tube engineering department in Schenectady, New York, for three years. It was during this time that he married Lucile Laura Salter on April 8, 1938. He had met Lucile Salter on campus at Stanford. She was a Californian who had been raised in the San Francisco bay region. Shortly after his marriage he entered a second, and now famous, partnership with William Hewlett.

Of his four children, the eldest and the only son, David Woodley, appears to have shown an early aptitude for science and mathematics, though a recent interest in the classics has drawn him to Perugia, Italy, for summer study before returning to Stanford in the fall.

David Packard's growing leadership in the electronics industry has been superimposed on a natural reticence which makes him shun personal publicity as much as is possible. But he does not shun personal responsibility for engineering projects under development, working with his

research staff as closely as time allows. This is quite evident in that he not only holds patents in the electronics measuring field, but he has several others now pending.

Though the demands on his time could be self-consuming if he let them, he manages to relegate as much routine business to others as is possible so that he can keep a day that is not too heavily scheduled. This allows him time to work with his research people or, equally important, time to reflect over important decisions. As he noted, one of the evils of a too-demanding schedule is "off-the-cuff" decisions which are not always the right decisions.

He is notably proud of the fact that Hewlett-Packard manufactures more than 15,000 components for their own equipment, thereby assuring themselves of having top-quality, top-precision parts for their electronic instruments, as he feels a high degree of responsibility for turning out instruments that meet the most meticulous of standards. As David Packard says, if their equipment isn't built with a fine degree of accuracy, how can it, in turn, be used to test the accuracy of other equipment?

He is not only pleased that his new plant is equipped with the best in environmental testing labs and human engineering labs, does its own electroplating, makes printed circuits, fabricates transistors, makes its own injection-mold plastic components, but also, that it has a truly workable, profit-sharing plan. The employees not only receive incentive payments and a stock bonus, but they share in employee-owned sidelines. And the fact that all the employees know him when he tours the plant is not half as surprising as the number that he knows by name.

To show to what a high degree the spirit of camaraderie goes, during our tour of his plant, a man working in a



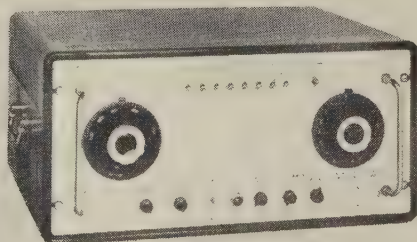
David Packard, left, becomes a shareholder in a local Junior Achievement organization by purchasing stock from Bruce Fuchs of Los Altos, California. The firm, engaged in manufacturing and selling perforated wastebaskets, is managed and operated by teenagers and is sponsored by Hewlett-Packard.

fabrication shop stopped Mr. Packard and showed him pictures of his horse. "I was wondering if you might be interested in having him for your ranch," the man said.

Mr. Packard asked him some questions about the horse and then said, "You know where my ranch is, don't you?" The man nodded. "Then take your horse out there and talk to the foreman. If we can use him, we'll buy him."

(Continued on page 28)

SWEEP GENERATORS FOR THE MICROWAVE FREQUENCIES 950-2450 mc



Telonic's new ED-1A and ED-4A Sweep Generators provide a flat, stable, swept signal source for operation in the region of 950 to 2450 mc. The ED-1A operates in the 950 to 1800 mc range, and the ED-4A covers 1450 to 2450 mc. Both instruments feature variable sweep width and have an output of over 0.3 volts RMS into 50 ohms.

The instruments use a 6AF4A tube to excite a harmonic generating diode that provides an output, filtered to deliver only the second harmonic. Signal level is well isolated from the source to the load and is held constant by a leveling circuit.

Several accessories such as harmonic markers, fixed markers, and detectors are available to extend usefulness of both instruments in laboratory-type applications.

Model	Center Frequency Range	Swept Range	Swept Width	Price
ED-1A	1000-1700 mc	950-1800 mc	.05-8%	1495.00
ED-4A	1500-2400 mc	1450-2450 mc	.05-8%	1495.00

For complete data on the ED series or other Sweep Generators and accessories write to

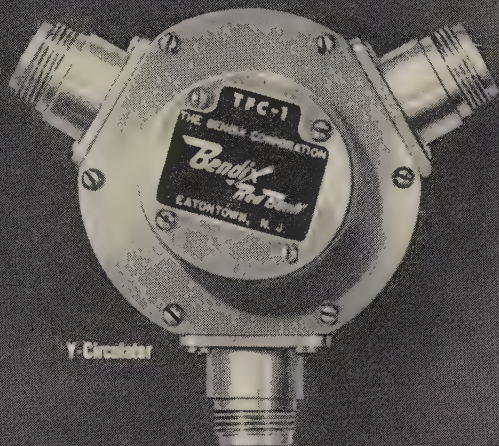
Telonic INDUSTRIES INC.
Beech Grove, Indiana



Bendix Craftsmanship at work for you



Phase Shifter



Y-Circulator



Attenuator

TYPICAL SPECIFICATIONS

	Phase Shifter	Y-Circulator	Attenuator
Frequency Range	5200 to 5800 mc	4700 to 5700 mc	4900 to 5800 mc
Insertion Loss	1 db max.	0.4 db max.	1 db max.
Impedance	50 ohms	50 ohms	50 ohms
VSWR	1.30 max.	1.20 max.	1.25 max.
Power Handling Capacity			
Average	5 watts	10 watts	5 watts
Peak	5 kilowatts	10 kilowatts	5 kilowatts
Temperature Range	-55°C. to +85°C.	-55°C. to +85°C.	-55°C. to +85°C.
Diameter	1.12"	2.375"	1.12"
Weight	6 oz.	11 oz.	6 oz.

NEW BENDIX® MICROWAVE FERRITE DEVICES.* **1** The Electrically Variable Phase Shifter, TFP-1, can produce phase shifts in excess of 90° over a minimum bandwidth of 10%. Chief uses are as phase modulator, fast shift, and in a wide variety of r-f direction finding devices. **2** The Y-Circulator, TFC-1, offers at least 20 db isolation with less than 0.4 db insertion over bandwidth exceeding 20%. Ideal for use with masers, and parametric amplifiers. **3** The Electrically Variable Attenuator, TFA-1, has a range exceeding 25 db over a minimum bandwidth of 15%. Useful in fast AGC circuits and remote level control applications. Write today.

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Applied Research inc.

LOW NOISE **RF** AMPLIFIERS

NOISE FIGURES

LESS THAN

1 DB at 30 MC
3 DB at 300 MC

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No Critical Alignment

Amplifier Model UH-2(A)SP is available at any preset frequency between 30 and 300 MC. This amplifier is a two tube unit with broadband response, high gain, and low noise figure. The unit requires no additional air cooling supply, as natural ventilation is used. The amplifier and its power supply are assembled on a 19" L x 3½" H panel suitable for rack mounting. Small size and low weight are featured in the rugged amplifier chassis.

Specifications of the amplifier are given below.

SPECIFICATIONS — MODEL UH-2(A)SP AMPLIFIERS

Frequency range:	Center frequency between 30 MC and 300 MC
Bandwidth:	Up to 10% of center frequency
Gain:	Greater than 20 DB (function of freq. and BW)
Noise figure:	<1 DB at 30 MC to <3 DB at 300 MC (function of freq. and BW)
Source impedance:	50 ohms
Output impedance:	50 ohms
Connectors: input	Type BNC, or N
output	Type BNC, or N
power	2 prong motor base receptacle
Power requirements:	115 VAC, 60 cps, 25 W
Dimensions:	19" L x 3½" H x 6½" D
Weight:	12¾ lbs.
Finish:	Gray enamel panel

For additional information write

Applied Research inc.

76 South Bayles Avenue, Port Washington, N. Y.

PACKARD

(Continued from page 26)

Another interesting point is that he encourages key groups to launch their own enterprises such as Dymec and Paeco, though he insists that other companies do this to as great a degree as does Hewlett Packard. He shrugs off the Christmas bonus which last year was seven per cent of a year's pay to all employees with, "When they have done a good job all year, they deserve a bonus."

Yet, he is not satisfied with the status quo. As David Packard remarked, "If you think you have reached the perfect solution to your problems, then you might as well quit right now." He believes that things can always be better than best.

He is obviously a man who subscribes to horizons unlimited, his own interests being on a scope much broader than the instruments he manufactures could possibly measure, encompassing such diverse fields as education, international affairs, farming and medicine. Concerning the latter, he recently witnessed an open-heart operation, and though he admitted to feeling faint when they began, he was soon so engrossed with the surgeon's skill that he watched the remainder of the operation with open admiration.

David Packard is not a man who just samples the well of his interests, but drinks deeply from them with a probing and inquiring mind. For instance, on a recent trip to Russia in company with 34 other business men at the invitation of Deputy Premier Anastas A. Mikoyan, he not only tried to observe and evaluate the Russian electronics technology, but also their farming and educational systems.

On visiting two meter factories in Russia, he found them making a complete line of measuring instruments including voltmeters, ammeters, etc., with mirror scales, and much like corresponding products in this country. He observed they used a great deal of die-casting and felt they had been doing a creditable job. He found, also, that there seemed to be more emphasis on quality rather than quantity.

On visiting the State Leningrad Electrical Machine Works, a plant originally founded by the Germans and still using much German machinery, he found that of the 10,000 people employed there, 450 were graduate engineers and that altogether something over 1500 technical people were working there. The engineer's average salary was 3 1/2 times the average wage in the factory.

If the plant exceeds its quota, a percentage is added to the employees' base pay. In one plant it averaged 75 per cent above base pay for the entire year. But this is most misleading if you were to compare the Russian buying power with ours, Mr. Packard said. For instance, even with the above bonus added to an engineer's pay, he made only \$175 per month, and on the same scale the cheapest suit cost \$200.

But, outside the electronics industry, David Packard was most interested in the educational system of Russia, having long held a vital interest in education, once serving on the Palo Alto School Board and now serving as a trustee of Stanford University.

Though he found that Russia emphasizes science, requiring four years of physics from seventh grade, for example, he was surprised to find that their fourth year of physics was not much more comprehensive than high-

school physics in this country, the earlier years of it being more on the order of our general science courses. But he was impressed by the fact that four years of physics was required of all students, that it was not an elective as it is in this country.

He was very impressed with the universities of which there are 39 in Russia. To illustrate the emphasis the Russians put on education, they not only don't charge students tuition, but give them a living allowance, and the university professors are among the highest paid people in the country. This emphasis naturally causes tremendous competition in their educational system. But once a youngster fails his exams, he has little chance to return to school for further study.

As for education in this country, David Packard feels that we are finally breaking out of the web of progressive education which has held such a long and destructive hold in our institutions of learning. And he feels we must use every effort to get down to hard-core subject matter in our schools with a definite stress on the basic three "R's." As he remarked, the amount an engineer or scientist or doctor must know now compared to what was required in his field twenty years ago is overpowering, and how we are to teach so much more in the same time span is a problem of some magnitude.

When asked what he thought of the criticism that engineers and scientists often tend to be overly job oriented and not too knowledgeable in other fields, he said that it is true of men in most professions and was an old battle between those who wanted the well-rounded students with a smattering of knowledge in all fields and those who believe in only educating people extensively in their chosen professions. He personally had no concrete solution to the problem.

Certainly he does not believe that more humanities for the scientists and more science for the humanitarians is the answer. But he definitely believes that with certain subjects presented earlier in school life, such as the recent high-school programs which accelerate the able children through the freshman year of college in high school, a student might be able to find time for delving into courses outside the required curriculum for his particular field. He also subscribes to industry having a responsibility



David Packard, right, receives an award from Sports Illustrated magazine as a college football letterman who 25 years later had distinguished himself in his profession and in community affairs.

toward education by supplying scholarships and hiring students for summer jobs.

As for those who have been sputnicked into tearing apart our country's accomplishments in science and engineering, he literally throws his hands into the air. "Definitely Russia is making rapid strides in these fields, but not as rapid as she would like you to believe. What the United States needs is to stand up and have more self-confidence in her abilities and accomplishments." As he said at the recent WESCON convention where he was keynote speaker, "We have failed to appreciate fully and take advantage of our own strengths and capabilities, both our military capability and the importance of our own traditions and ideas and the good will they generate."

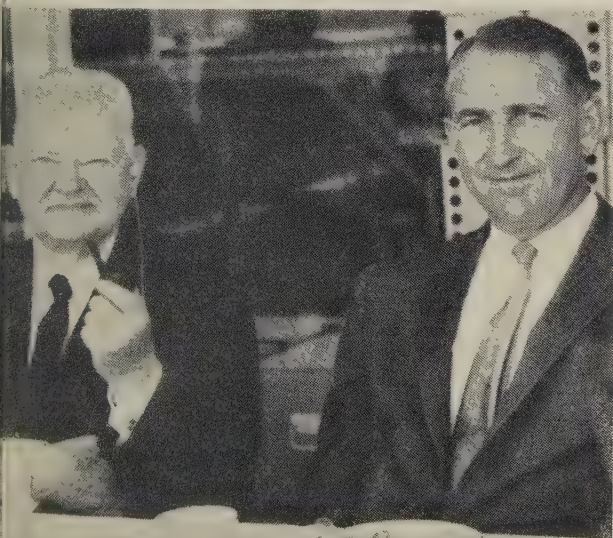
On being asked how he escapes from the complexities of his life, he smiled and visibly relaxed, settling deeper into his chair. "Bill and I have a cattle ranch near Evergreen. We run 400 to 500 head of cattle on the 21,000 acres. It's not the best ranch in the world, but it suits us. Besides, it's close enough to reach in an hour's drive from the plant. Yesterday, I tried one of the new bulldozers on the place and worked on building a road."

When horses were mentioned, he said that he wasn't interested in horses just for riding's sake. If they could get him to a job in time, fine, but if it was some distance away he'd rather rely on a jeep.

He also talked about how much he enjoyed hunting and fishing and regretted he didn't have as much time for the safaris he used to take, though he does occasionally drive or fly up to Idaho or Montana for a chance at elk or other big game. These are hobbies that had their beginnings in his childhood in Colorado with the Rockies at his doorstep.

But David Packard has obviously come a long way from those beginnings with plans for expansion of not only his own personal horizon but for the horizons of Hewlett-Packard which is already planning an addition to its Boonton, New Jersey, plant this fall.

When asked, "What are we working on now?", his answer was, "Anything in any field of electronic instrumentation that is needed. If it can be done, we'll do it. We aren't interested in expansion for expansion's sake. We are only interested in doing an important or vital job that needs doing whether it's in industry or medicine or any other profession, and we let the chips fall where they may."



In honor of his 85th birthday, former President Herbert Hoover attends a luncheon at the Hewlett-Packard plant.

Engineer inspects Styroflex® cable installed on an antenna array at one of Pacific Scatter Communication System stations shown at right.

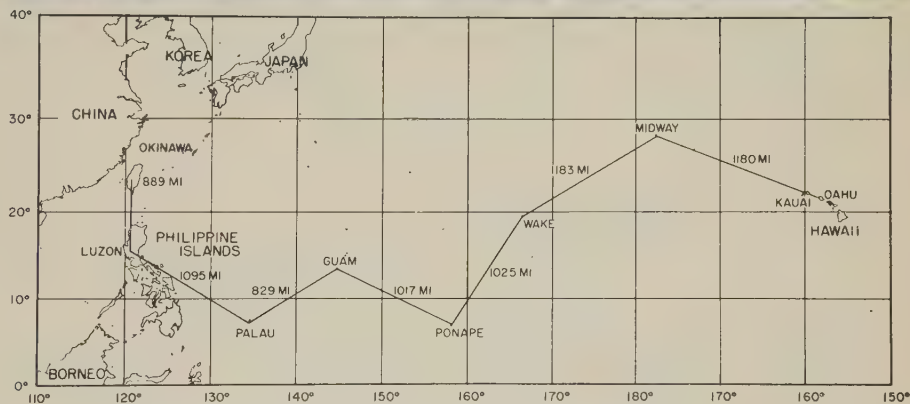
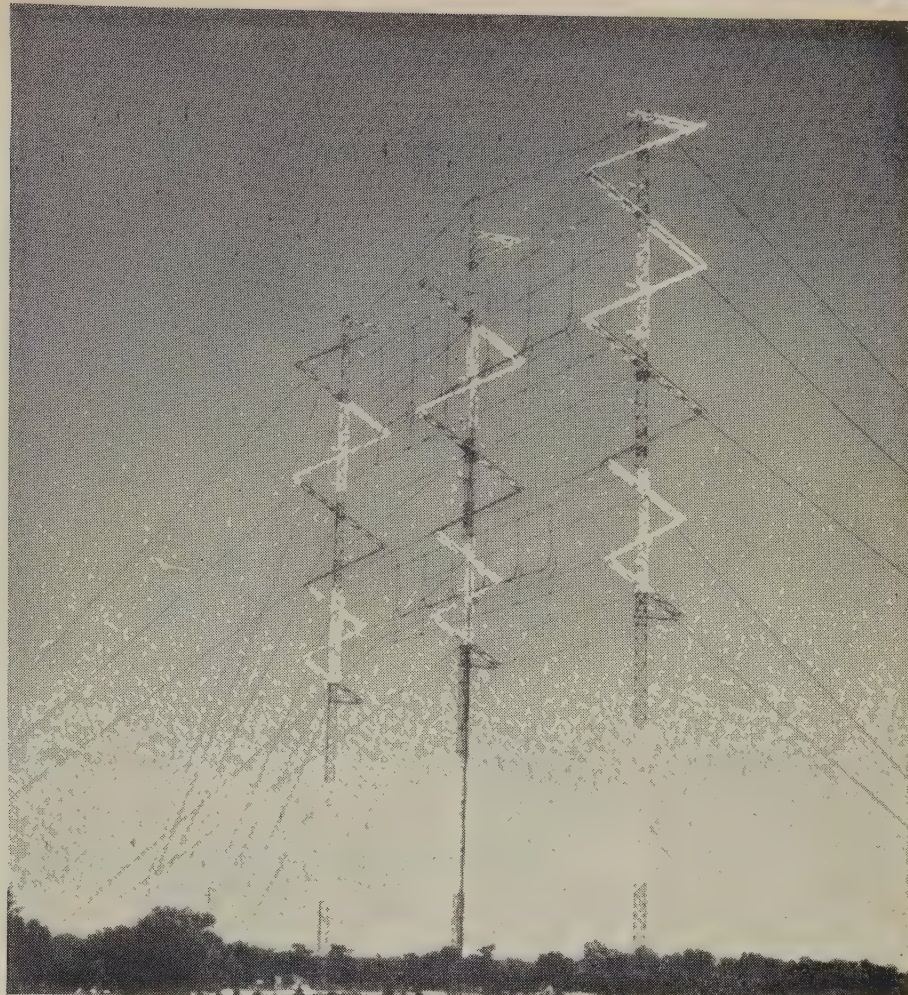


Over 40 miles of *Styroflex® Coaxial Cable* help assure

More than 200,000 feet of Styroflex® coaxial cables are in active use as balanced antenna feed lines in the recently completed Pacific Scatter Communication System stretching from the Hawaiian Islands to Okinawa. This trans-Pacific system, one of the largest and most advanced of its kind in the world, uses ionospheric and tropospheric propagation techniques that produce over 99% reliability. An important part of the Strategic Army Communications Network (STARCOM), the system was designed, developed and constructed by Page Communications Engineers, Inc. for the U. S. Army Signal Corps.

Each of the nine stations in the network is equipped with the same major component parts—transmitters, excitors, multiplex terminals and antennas. The cables used in the 200- and 400-foot antenna arrays range from 7/8" jacketed Styroflex® cable to 3 1/8" jacketed Styroflex® cable. About 7,000 feet of 1/2" jacketed Foamflex® cable is also used in the system. The Styroflex® cables were spliced in the field by an inner Heliarc welding process to assure noise-free connections required for successful duplexed antenna operation.

The extremely low inherent noise level and low attenuation of Styroflex®—together with this



Pacific Scatter Communication System reliability!

electric cable's stable electrical and mechanical properties—especially qualify it for the critical specifications of this STARCOM system. If your system require-

ments call for a cable with low loss and high reliability, investigate the successful record of Styroflex®!

(Photos courtesy of Page Communications Engineers, Inc.)

PHELPS DODGE COPPER PRODUCTS

CORPORATION

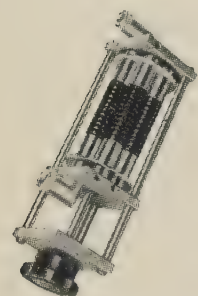
300 Park Avenue, New York 22, N. Y.



MINIATURIZED TURRET ATTENUATORS FROM 0 TO 10 KMC FOR IN-LINE AND PANEL MOUNTING

From MICROLAB, here is a complete line of miniaturized turret attenuators for use as laboratory instruments or components in military and field equipment.

M
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A
B



AS Series—

Six fixed attenuators mounted about a central shaft and selectively engaged by means of a coaxial switch. For use in the 4000 to 10,000 mc region, they are the only turret attenuators available that can be used in the X band range.

AT Series—

Similar in design to the AS Series, they are designed for use in the DC to 5000 mc range and are available in 2, 5 and 15 watts.



AV Series—

The smallest, lightest variable step attenuators available, they consist of six or more coaxial attenuators mounted within a single housing. Characterized by low VSWR and zero insertion loss, they are used from DC to 2000 mc.



AW Series—

Waterproof, environmental-resistant, variable step attenuators for use from DC to 4500 mc with low VSWR and zero insertion loss. Their low cost and rugged design make their use practical where other models are prohibitively expensive and delicate.

For in-line mounting.



AX Series—

Waterproof, environmental-resistant, variable step attenuators for use from DC to 4500 mc with low VSWR and zero insertion loss. Similar to AW Series attenuators but designed for front-panel mounting.

TURRET ATTENUATORS

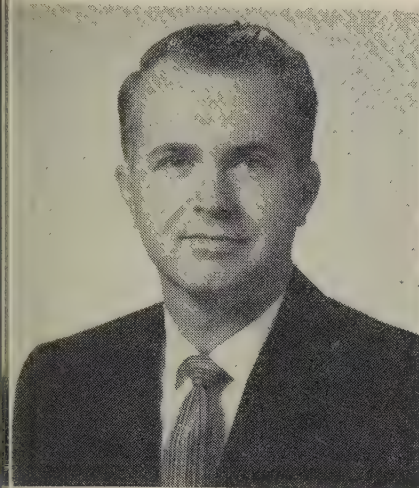
MICROLAB SERIES	AS	AT (2 watt)	AT (5 watt)	AT (15 watt)	AV	AW	AX
FREQUENCY RANGE (kmc)	4-10	0-5	0-5	0-5	0-2	0-4.5	0-4.5
ATTENUATION VALUES (db)	0-20	0-60	0-30	0-60	0-20 ⁽³⁾	0-30	0-30
MAXIMUM VSWR	1.40	1.30	1.40	1.40	1.25	1.30	1.30
ACCURACY (db) ⁽¹⁾	±0.5	±0.5	±0.5	±1.0	±0.7	±0.5	±0.5
POWER, AVERAGE (watts)	2	2	5	15	2	2	2
POWER, PEAK (kw)	2	2	3	3	1	2	2
OVERALL LENGTH (in.) ⁽²⁾	8.4	6.9	8.1	10.5	2.8	3.3	4.7
WEIGHT (oz.) ⁽²⁾	33	27	31	40	6.1	9.7	13.3
METHOD OF ADJUSTMENT	knob	knob	knob	knob	(4)	(4)	knob
PUSH-PULL MOTION REQ'D	yes	yes	yes	yes	no	no	no
PANEL MOUNTING	yes	yes	yes	yes	no	no	yes
CHASSIS MOUNTING	yes	yes	yes	yes	no	no	no
WATERPROOF	no	no	no	no	no	yes	yes
PRICE ⁽¹⁾ ⁽²⁾	280.00	250.00	340.00	430.00	150.00	220.00	240.00

NOTES: (1) 10 db nominal (2) Type N connectors (3) Per turret (4) Knurled finger grip on rotating tumbler

570
W. Mt. Pleasant
Avenue
Livingston, N. J.
WYman 2-5700

(Continued from page 22)

WHITTELSEY APPOINTED ADMINISTRATIVE DIRECTOR



Watkins-Johnson Co., Palo Alto, Cal., developer and manufacturer of electron devices and electronic systems, has announced the appointment of Stuart G. Whittelsey, Jr. as administrative director.

Whittelsey succeeds Fuller E. Callaway, III, who resigned to develop other business interests. The new administrative director came from Litton Industries, where for the past five years his duties included manager of the Dayton, Ohio, offices and manager of customer relations and contracts administrator for the Electron Tube Division, San Carlos, Cal.

A native of Berkeley, Cal., Whittelsey is a graduate of Stanford University and has an MBA degree from the Harvard Graduate School of Business. While an officer with the U. S. Air Force (1953-55) he served as procurement and production officer at Headquarters, Air Materiel Command.

He is an associate member of the Institute of Radio Engineers and a member of the American Marketing Association.

— m w j —

ANTENNA REFLECTOR CONTRACT AWARDED

Antenna Systems, Inc., Hingham, Mass., announces the award of a subcontract by Raytheon Co. for the design and production of ARSR-2 reflector assemblies.

These large radar antennas, approximately 50 feet x 20 feet, are being furnished by Raytheon to the Federal Aviation Agency for use in long range air traffic control systems. President Charles W. Creaser of Antenna Systems states that the units will be delivered to the Raytheon Wayland laboratory and North Dighton Surface Radar Operations plants over a period of several months extending into 1961.

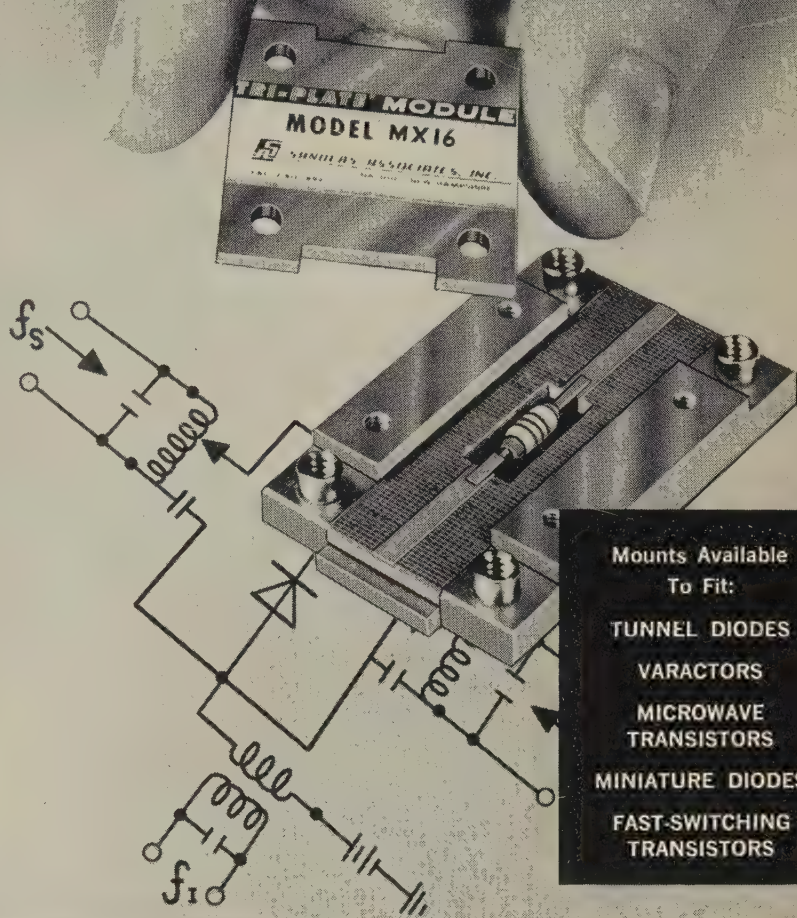
— m w j —

(Continued on page 34)

Circle Reader Service Card 20

NEW SEMICONDUCTOR MOUNTS

BRIDGE DESIGN GAP in microwave circuits!



Mounts Available
To Fit:

- TUNNEL DIODES
- VARACTORS
- MICROWAVE TRANSISTORS
- MINIATURE DIODES
- FAST-SWITCHING TRANSISTORS

MODULAR SANDERS TRI-PLATE® MOUNTS NOW AVAILABLE FOR ADVANCED SEMICONDUCTORS

This new Sanders strip transmission line development allows you to design the most advanced semiconductors into such applications as parametric amplifiers, harmonic generators, and transistor circuits.

Sanders Semiconductor Mounts are an important addition to the present line of on-the-shelf Tri-Plate strip transmission modules . . . and now permit designers to breadboard *almost any* microwave circuit in a matter of minutes. For complete specifications, prices and delivery schedules on Semiconductor Mounts or standard Tri-Plate module kits write today.

®Trademark Sanders Associates, Inc.



SANDERS ASSOCIATES, INC.

Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE

SUPER-DRY *Air...*

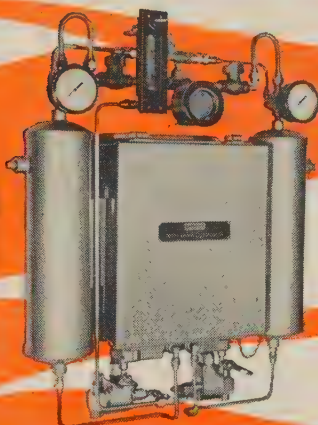
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for transmission media*

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DRYERS**

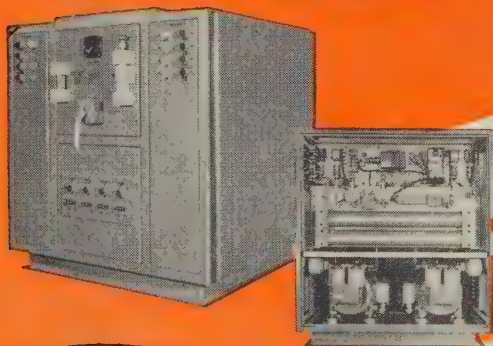


Dynamic desiccant dryers providing dewpoints below -100°F . No bothersome, expensive heaters. Completely automatic. Available in all capacity ranges. Install with compressor, or air supply of your choice...

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SYSTEMS**



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Super-dry air is your most economical, dependable dielectric for purging transmission lines and associated equipment. Trinity equipment is currently used by both the military and commercial design and manufacturing groups to assure maximum performance and greatest dependability.

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Thermocouples and Thermowells

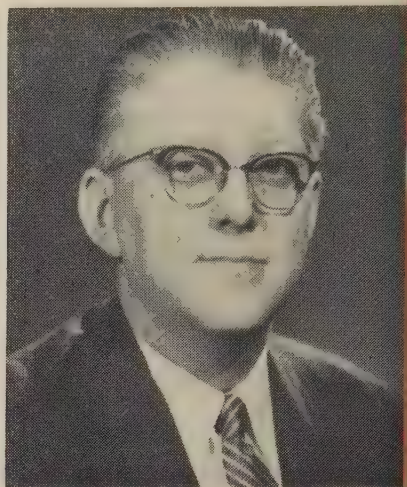
TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

Circle Reader Service Card 58

Industry News

(Continued from page 33)

**HARTMAN APPOINTED TO NEW
PHILCO RESEARCH POST**



Dr. Lawton M. Hartman of New York City and Philadelphia has been appointed Associate Director of Research — Operations at Philco Corp., Philadelphia, Pa.

The newly created position carries responsibility in areas of project administration and management, budgets and forecasting, and interdivisional liaison. With the Research Division since 1947 when he joined Philco as a consultant and member of the Technical Systems Planning Group, Dr. Hartman has recently been responsible for directing one of Philco's important space communication programs.

Dr. Hartman has had broad experience in the physics of ionized gases, upper atmosphere ionization and missile reentry. He earned a BS degree (with highest distinction) in Physics from Yale University in 1937. In 1947 he was awarded his MA in Chinese Language and Literature and the degree of PhD in Theoretical Physics from Yale. He has held graduate fellowships and teaching appointments at Harvard and Yale. Prior to joining Philco, Dr. Hartman was associated with atomic energy and ICBM programs at General Electric.

— m w j —

DORNE & MARGOLIN, COLLINS SIGN SALES AGREEMENT

Overseas sales for Dorne and Margolin Inc., Westbury, L. I., designer and manufacturer of airborne antennas and microwave components, will be conducted through Collins Radio International. D&M President Arthur Dorne has announced.

The foreign sales marketing program is a step in the overall expansion plan of the 12-year-old electronics firm, Mr. Dorne said. Under terms of their agreement, Collins will promote noncompetitive D&M products abroad.

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(Continued on page 36)

Circle Reader Service Card 22

the microwave journal

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DIRECTIONAL COUPLERS
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Copper Clad REXOLITE is one of
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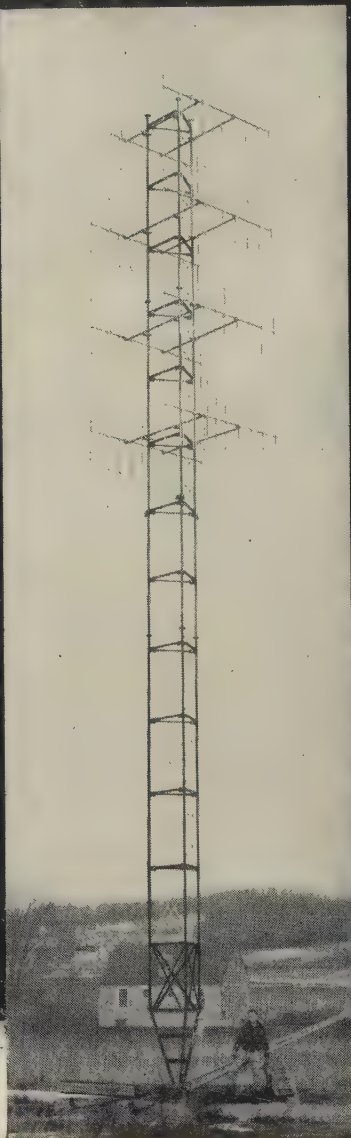
BRAND

REX

**WILLIAM BRAND-REX
DIVISION**

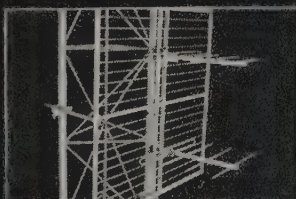
AMERICAN ENKA CORPORATION
31 Sudbury Road • Concord, Massachusetts

RUGGEDIZED YAGIS

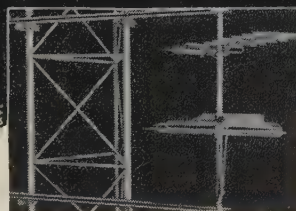


for communications

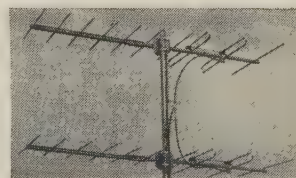
Taco Ruggedized Yagis are specifically designed to meet the performance parameters of the industrial and defense user. They are built to provide the highest electrical performance under all weather conditions. Tubing is $\frac{3}{8}$ " OD 6061T6 high strength aluminum alloy, reinforced with $\frac{3}{4}$ " OD telescoping sleeves at points of greatest stress. The antenna is of welded construction. Transmission line termination is a coaxial connector. The connector housing is filled with foamed plastic to eliminate condensation.



Ruggedized Yagis are available with screen-type reflectors, as single units or arrays of 2, 4, or more antennas.



All types of mounting hardware are standard accessories, for both vertical or horizontal polarization.



Mast-Mounting accessories assure positive azimuth positioning and dependability.

Taco Ruggedized Yagis are available in many models for various operations from 30 MCS to 500 MCS. Hardware is available for stacking two or more units of any model for additional gain. Power handling capacities range to 750 watts for single units, which may be raised through stacking arrays. Gain, directivity patterns, and front-to-back ratios are excellent, varying in characteristics according to the particular model chosen.

Write for complete details, including all mechanical and electrical specifications...

TACO

DEFENSE & INDUSTRIAL DEPT.

TECHNICAL APPLIANCE CORPORATION, Sherburne, New York.

Industry News

(Continued from page 34)

RICHARDSON NAMED NSIA VICE PRESIDENT

John H. Richardson, vice president of Hughes Aircraft Co., Culver City, Cal. has been elected third vice president of the National Security Industrial Association. Richardson, who is in charge of marketing at Hughes, was also elected trustee.

— m w j —

DE GRASSE JOINS MICROWAVE ELECTRONICS



Dr. Robert W. De Grasse has joined Microwave Electronics Corp., Palo Alto, Cal. as an engineering section head. Dr. Stanley F. Kaisel, president, has announced Dr. De Grasse will take leading responsibility in the development of a program in low-noise microwave devices.

Dr. De Grasse came recently from Murray Hill, N. J., where he was a member of the technical staff of Bell Telephone Laboratories for three years. There he was associated with the Echo balloon satellite program, having participated in the design of the BTL ultra-sensitive maser receiver used in space communication experiments.

A graduate in Electrical Engineering from Cal Tech, Dr. De Grasse spent two years with Jet Propulsion Laboratory as the flight radar engineer for the Corporal missile development program.

He came to Stanford University in 1953 as a research assistant at the Electronics Research Laboratories, continuing his graduate work concurrently. His M.S. and PhD degrees in Electrical Engineering are from Stanford.

A member of the Institute of Radio Engineers, Dr. De Grasse is active in several professional groups — most prominently, those on Microwave Theory and Techniques and Electron Devices. He is also a member of Sigma Xi.

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(Continued on page 38)

the microwave journal

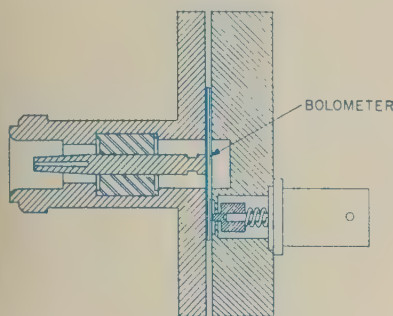
Bolometers, Barretters, and Thermistors

You have often been asked, "What is the difference between a bolometer, a barretter, and a thermistor?" At PRD the following is generally accepted: *Bolometer* is a general term which describes a temperature-sensitive element whose resistance changes as it dissipates microwave power. Bolometers include (a) thin short lengths of Wollaston wire, (b) evaporated metallic film, (c) small beads of semiconductors. The wire and film types are called "bolometers" or "barretters" and have a positive temperature coefficient. The semiconductor is called a "thermistor" and has a negative temperature coefficient.

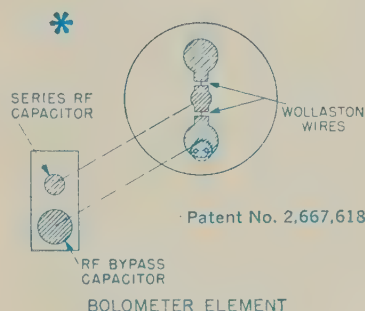
Power Measurement Equipment

The bolometer, plus appropriate mount, provides us with an accurate, dependable means of measuring microwave

Each bolometer has a nominal operating resistance of 200 ohms when biased. For low power (1 mw max.), the PRD 631-C uses short lengths of



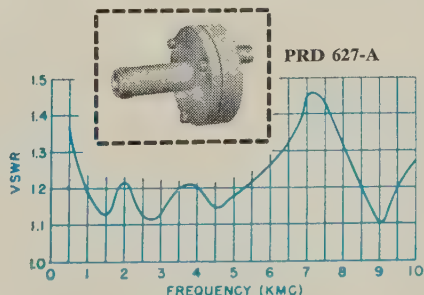
BOLOMETER MOUNT



Wollaston wire which when deplated cannot be seen by the naked eye but must be delicately constructed under powerful microscopes. The metallic film units (PRD 631-D) are high power devices and can dissipate up to 100 mw.

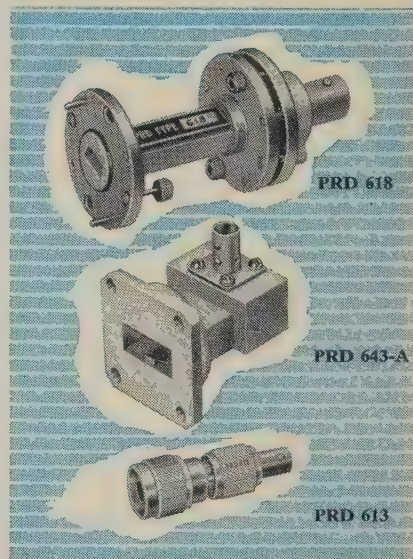
Mounts

PRD bolometer mounts, such as the PRD 627-A, require no tuning, operate over a frequency range of 500 to 10,000 megacycles/sec, and are designed to insure high efficiency. The mount provides a low VSWR over the



entire band and allows for easy replacement of bolometer elements without retuning. A typical VSWR curve is shown.

PRD produces a variety of mounts



and bolometers. These include coaxial, waveguide, tunable, and broadband. Shown are, from top to bottom, a Waveguide Bolometer Mount (PRD 618) which operates from 26.5 to 40 KMC/S, a Waveguide Thermistor Mount (PRD 643-A) for 8.2 to 12.4 KMC/S, and a Coaxial Crystal and Bolometer Mount (PRD 613) for 1 to 12 KMC/S.

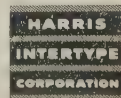
Precision in Production

PRD offers as standard catalog items some 34 different mounts and seven types of bolometers and thermistors. Our assembly line turns out several hundred bolometers alone in a week, all of which undergo rigorous stability and humidity tests after construction. PRD also produces, of course, all necessary associated equipment for power measurement. For more theoretical information, write for PRD Report Vol. 1, No. 4, "Microwave Power Measurements" or contact our Applications Engineering Department.

We have many interesting openings for engineers...contact Mr. John R. Zabka

PRD
ELECTRONICS, INC.
A Subsidiary of Harris-Intertype Corporation
Formerly Polytechnic Research & Development Co., Inc.

202 Tillary Street, Brooklyn 1, N. Y.
ULster 2-6800
1608 Centinela Ave., Inglewood, Cal.
ORegon 8-6922

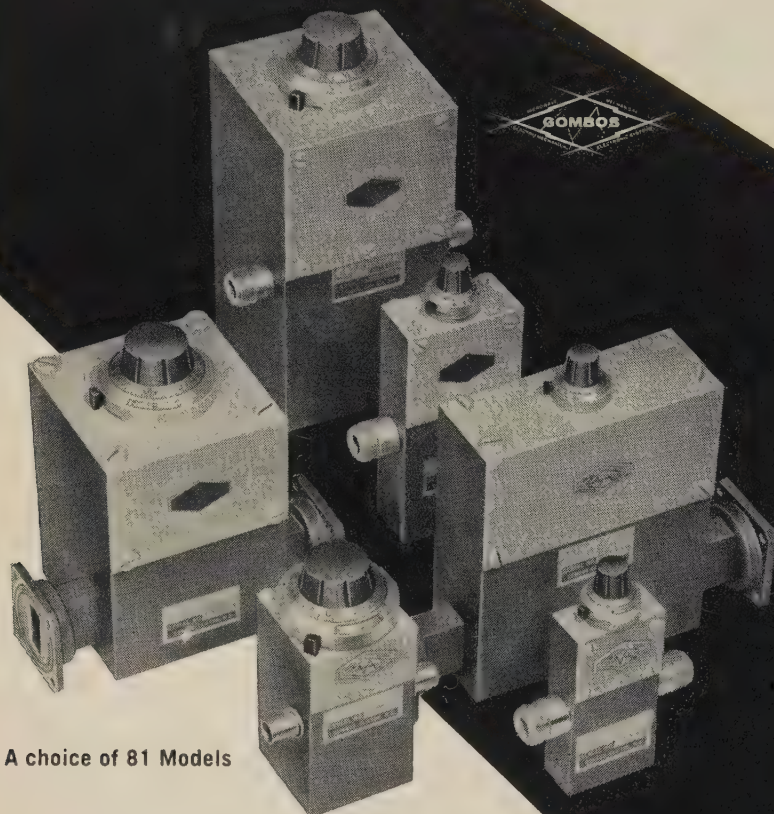


accommodate bolometers, barretters, or thermistors and reads power directly to 100 milliwatts.

Design Details

The drawing above is the PRD 627-A Broadband Coaxial Bolometer and Thermistor Mount which houses the PRD 631-C (wire type), PRD 631-D (film type), and PRD 631-G (thermistor). The two general types of bolometers manufactured by PRD are Wollaston wire and evaporated metallic film applied to thin mica discs. The PRD 631-G Thermistor uses two semiconductor bead elements and has excellent stability characteristics.

TUNABLE BAND PASS FILTERS



A choice of 81 Models

A COMPLETE LINE FROM 500MC TO 18,000MC

- Single knob tuning
- 2, 3, & 4 Section models offer a selection of rejection characteristics
- Low insertion loss (1.0 D.B. Max.)
- Coaxial or waveguide application

The John Gombos Co., Inc. line of TUNABLE MICROWAVE BAND-PASS FILTERS is designed for laboratory application such as Image Filters, Noise Measurements, Harmonic Rejection, Frequency Selection and Spectrum Analysis. These filters are also designed for systems applications such as Video or Superheterodyne Preselection, Resonant Diplexing, Frequency Discrimination, Multiplexing and Band Elimination.

JOHN
GOMBOS
CO., INC.
WEBRO ROAD, CLIFTON, N. J.

WRITE TODAY for literature on the John Gombos Co., Inc. line of Triode Oscillators and Amplifiers, Tunable Band Pass Filters and Front End Assemblies. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

BOMAC ANNOUNCES TWO APPOINTMENTS

Bomac Laboratories, Inc., Beverly, Mass., announces the appointment of Dr. Arthur O. McCoubrey as manager of Research and Dr. Joseph H. Holloway as manager, Resonance Physics Research.

Dr. McCoubrey received his BS degree in Applied Physics from California Institute of Technology in 1943. After graduation from Cal Tech., he joined Westinghouse Electric Corp. near Pittsburgh, Penn. While there he completed graduate studies at the University of Pittsburgh leading to a PhD degree.

He worked on the Atomic Bomb Project at the University of California Radiation Laboratory on isotope separation apparatus. In 1946 he was responsible for installation and operation of telemetering links at the Atomic Bomb Test at Bikini Atoll.

In 1957 he joined National Company in Malden, Mass., as manager of the Physics Department which was devoted to applications in resonance physics. The principle program at National involved the development of atomic beam resonators for ultra precise frequency control based upon the magnetic hyperfine structure of cesium.

Dr. Holloway received his BA degree from Wooster College, Wooster, Ohio, and from M.I.T., Cambridge, Mass., received a SB Degree in Physics. He also earned his PhD from M.I.T. in 1956. He attended M.I.T. on a National Science Foundation Fellowship and while there also worked as a research assistant prior to receiving his PhD.

Prior to joining Bomac, Dr. Holloway was associated with the National Company, Malden, Mass., where he was section manager of the Basic Physics Section. Most of his work while at National was related to the development of a cesium atomic beam frequency standard.

— m w j —

WEINER NAMED VICE PRESIDENT OF PHILCO GROUP

The appointment of James R. Weiner as vice president-engineering for Philco Corp.'s Government and Industrial Group, Philadelphia, Pa., has been announced by Henry F. Argento, vice president and general manager of the Group.

In this position, which is a new one in G & I, Mr. Weiner will report directly to Mr. Argento. His responsibility will be the coordination of the engineering and development work of the five divisions with the Philco Group. These divisions include Communications and Weapons Systems, Computer, Communications Systems, Western Development Laboratories, and Sierra Electronics.

Before joining Philco, Mr. Weiner was

the microwave journal

associate director of Research and manager of the Communications and Control system for the Discoverer, Samos, and Tidas programs at the Lockheed Missiles and Space Division at Palo Alto, Cal. Prior to joining Lockheed, he was assistant vice president for Engineering with Remington-Rand Univac, a division of the Sperry Rand Corp.

Mr. Weiner was closely associated with the development and design of the Binac and Univac systems, the solid-state Univac and the Larc, an ultra high speed, solid-state computing system.

He received his BS degree in Engineering Physics from the University of Illinois and his Master of Electrical Engineering degree from Polytechnic Institute of Brooklyn, and did further graduate work at Massachusetts Institute of Technology and Harvard University.

—mwj—

POLARAD APPOINTS NEW MARKETING DIRECTOR



Appointment of Joseph P. Schindler as director of marketing, has been announced by Mr. Paul H. Odessey, executive vice president of the Polarad Electronics Corp., Long Island, N. Y. In this new capacity Mr. Schindler assumes the responsibility of achieving Polarad's future sales goals. The complete industrial sales complex, which includes the Industrial Sales, Advertising, and Market Research departments is now combined under the administration of the director of marketing.

Mr. Schindler joined Polarad Electronics in 1950 as a project engineer. In this position he was engaged in the development of microwave signal generators and receivers. Since then Mr. Schindler has been closely associated with the company's equipment development efforts, in the positions of Group Leader and Section Head.

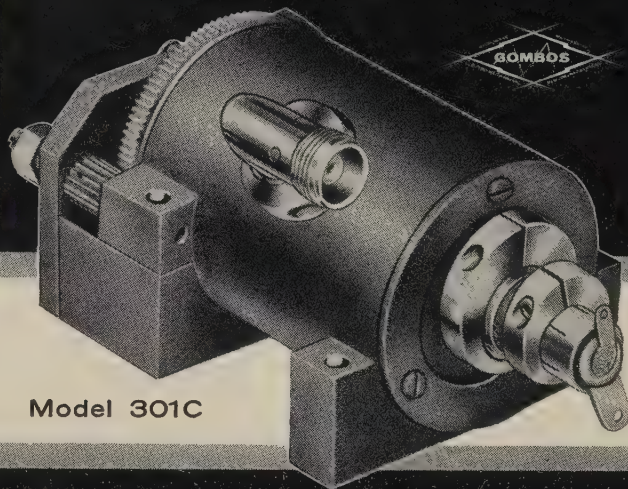
In 1957 he was appointed assistant to the vice president in charge of Engineering, and Department Head of the Ground Support Equipment development.

—mwj—

(Continued on page 41)

1 KW "C" BAND

Pulsed TRIODE Oscillator



Model 301C

- ± 1 MC FM at 20 G's, 20-2000 cps
- ± 20 KC per degree C
- No mode skipping
- Less than 1 MC pushing figure
- Low pulling figure
- Long mean-time-to-failure life
- No special pulse shaping required
- Milli-microseconds rise time
- No magnetic shielding required

2 KW "S" Band Model 302S also available

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WEBRO ROAD, CLIFTON, N. J.

We are a recognized, quality manufacturer of a complete line of Triode Oscillators, Amplifiers and Multipliers from "L" Band through "C" Band. We also produce a complete line of Tunable Band Pass Filters from "L" through "Ku" Band.

WRITE TODAY For Descriptive Literature. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

LITTON INDUSTRIES

MICROWAVE TUBES

P, L, S, C, X, K BANDS

KLYSTRONS

Type Number	Frequency Range Megacycles	Peak Power (Minimum) Mega-watts	Cathode Pulse Length Micro-seconds	RF Duty Ratio	Remarks
L-3270	1250 to 1350	2	8	0.0025	Broadband (100 megacycles between 2 megawatt points)
LT-7504 (L-3035)	1240 to 1360	2.2	8	0.0025	Long range search radar
L-3257	1280 to 1330	4	30	0.0003	For linear accelerator
L-3227	1280 to 1330	5	8	0.002	For linear accelerator
L-3250	1250 to 1350	10	7.2	0.0015	Long range search radar and linear accelerator
L-3387	1250 to 1350	30	7.2	0.0033	Long range search radar
L-3302	2855	10	7.2	0.0015	For linear accelerator and radar
L-3355	1250 to 1350	20	7.2	0.0015	Long range search radar

TRAVELING WAVE TUBES

Type Number	Frequency Range Megacycles	Power Output	Focusing	Duty Factor
L-3266	7000 to 11,000	20 mw	PPM	CW
L-3236	7000 to 11,000	2 W	PPM	CW
L-3470	4000 to 8000	20 mw	PPM	CW
L-3471	4000 to 8000	2 W	PPM	CW
L-3472 *	8500 to 9600	10 W	PPM	CW
	7000 to 11,000	5 W		
L-3264 *	100 to 300	100 W	Solenoid	CW

* In development

M-TYPE BACKWARD WAVE OSCILLATORS

Type Number	Frequency Range Megacycles	Power Output	Focusing	Factor	Remarks
L-3148	8500 to 11,000	150 watts minimum	Permanent magnet	CW	No holes in a 1.5/1VSWR

A complete line of M-BWO's is available but classified

PULSE MAGNETRONS

Type Number	Frequency Range Megacycles	Peak Power (Min.) KW	Duty Ratio	Remarks
L-3204	8800±25	0.04	0.25	Extremely high duty
L-3105	9300±40	0.10	0.027	Highly ruggedized; frequency stable
L-3028	9280 to 9320	0.12	0.027	Frequency stable; pulse train capability
L-3379	8800 to 9500*	1.0	0.003	Highly ruggedized; frequency stable
L-3058	9330 to 9350*	1.0	0.003	Frequency stable
L-3358	16,000 to 16,500*	1.0	0.001	Highly ruggedized; frequency stable
L-3380	8800 to 9500*	2.0	0.002	Highly ruggedized; frequency stable
L-3359	16,000 to 16,500*	2.0	0.001	Highly ruggedized; frequency stable
L-3381	8800 to 9500*	3.0	0.001	Highly ruggedized; frequency stable
L-3382	8800 to 9500*	4.0	0.001	Highly ruggedized; frequency stable
LT-6233	9280 to 9345	7.0	0.003	High duty beacon magnetron
L-3103	8500 to 9600*	30.0	0.002	High duty version of LT-6543
L-3168	9375±30	30.0	0.002	High duty version of LT-4J52A
L-3306	16,000 to 17,000*	30.0	0.002	High duty version of L-3083A
L-3083A	16,000 to 17,000*	60.0	0.001	Recommended for new systems
LT-6543A	8500 to 9600*	65.0	0.001	Recommended for MTI systems
L-3305	8600 to 9500*	65.0	0.001	Recommended for frequency diversity
LT-6510	9375±30	65.0	0.001	Recommended for MTI systems
LT-4J52A	9375±30	70.0	0.001	Recommended for new systems
L-3312	8500 to 9600*	200.0	0.001	In development
L-3313	8600 to 9500*	200.0	0.001	Hydraulically tunable for frequency diversity
LT-4J50A	9375±30	225.0	0.001	Recommended for new systems

*Fixed frequency versions available generally throughout tunable range.

CW MAGNETRONS

Type Number	Frequency Range Megacycles	Minimum Power Watts	Remarks
L-3456	350-590	500	These CW Magnetron may be pulsed to approximately 2 kilowatts peak power and are recommended for component testing
L-3459	590-975	500	
L-3465	975-1500	400	
L-3464	1500-2350	400	
L-3460	2350-3575	500	
L-3461	3575-4975	400	
L-3467	4975-6175	400	
L-3468	6175-7275	300	
L-3462	7275-8775	300	
L-3463	8775-10,475	250	

CROSSED-FIELD FORWARD WAVE AMPLIFIER TUBES • BARRATRON® TRANSMITTING TUBES • MINIATURE NOISE SOURCES • DUPLEXERS & TR TUBES • DISPLAY TUBE

"CAPABILITY THAT
CAN CHANGE
YOUR PLANNING"



LITTON INDUSTRIES
Electron Tube Division
San Carlos, California

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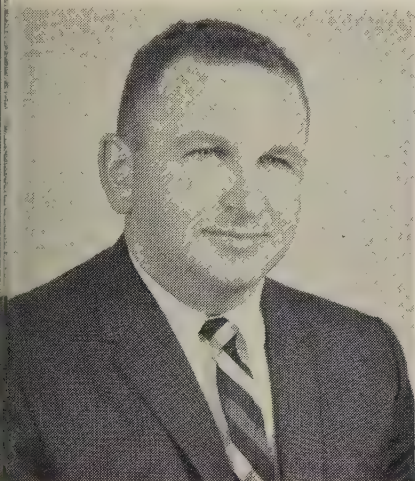
GT&E ACQUIRES MAJORITY INTEREST IN ITALIAN FIRM

General Telephone & Electronics International Inc., international subsidiary of General Telephone & Electronics Corp., New York, N. Y., has acquired a majority interest in the Radio Communications Division of Magnetti Marelli, Milan, Italy, according to an announcement by Donald C. Power, chairman and chief executive officer of GT&E.

Mr. Power said that a new company has been formed, known as Marelli Lenkurt, S.p.A., located in Milan. The new company will specialize in the manufacture of Marelli microwave radio and carrier apparatus, Lenkurt carrier and transmission equipment, and Automatic Electric S.A.T.A.P. (Milan) carrier and radio equipment, which division of the latter is being merged with Marelli Lenkurt.

—mwj—

IRVING ZWEIFLER JOINS GENERAL MICROWAVE



General Microwave Corp., Farmingdale, N. Y. has announced that Irving Zweifler has joined its organization as vice president and manager of manufacturing. In this capacity, Mr. Zweifler will have overall responsibility for General Microwave Corp.'s electronic and microwave production, test and calibration.

Mr. Zweifler has had extensive experience in the microwave and electronic fields including approximately 10 years with PRD Electronics, Inc. where he was most recently employed as manager of Production. Prior to PRD, Mr. Zweifler was assistant test supervisor at the Pilot Radio Corp.

Mr. Zweifler received the degrees of BEE, Summa Cum Laude, 1949 and MEE, 1952 from the Polytechnic Institute of Brooklyn and the degree of MBA in 1956 from New York University. He is a member of Tau Beta Pi, Eta Kappa Nu, Sigma Xi and IRE.

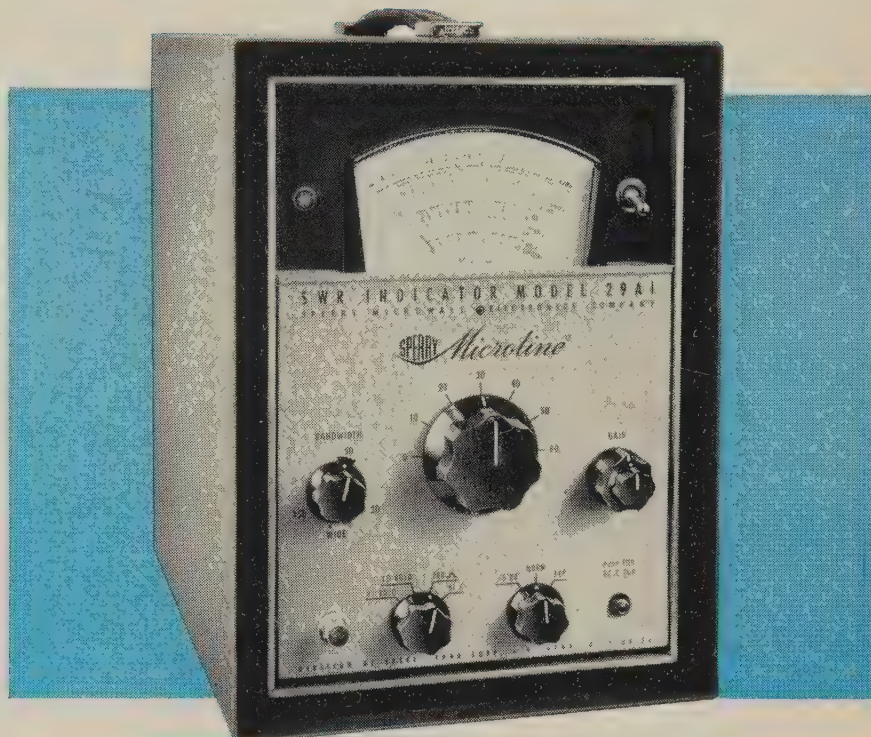
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(Continued on page 42)

December, 1960

COMPARE... and you'll use

SPERRY Microline[®] 29A1 SWR Indicator



IMMEDIATE DELIVERY



\$200

Many features designed into the 29A1 are not normally included at such a low price. And it is available for immediate delivery.

Adjustable bandwidth allows maximum sensitivity with freedom from modulator drift errors. Positive protection against bolometer burnout. Expanded scale with automatic gain compensation. Push-to-read bolometer current. Plus 5 db gain supplement always assures accurate upscale meter readings. Designed for ease of operation.

Frequency:	1000 cps $\pm$ 1%
Sensitivity:	0.1 uv for full scale deflection
Noise Level:	Less than 0.03 uv at min. bandwidth
Bandwidth:	Wide Band: 300-5000 cps Narrow Band: continuously adjustable 30-150 cps
Range:	70 db adjustable in 5 db steps accurate to $\pm$.1 db per step
Recorder Output:	0 to 1 ma, 1500 ohms, one side grounded
Dimensions:	Approx. 8" x 11" x 12"



SPERRY MICROWAVE ELECTRONICS COMPANY, Clearwater, Florida, Division of Sperry Rand Corporation

Circle Reader Service Card 28

To be frank, why pay for more than you need?

Canoga's MPS-26 instrumentation radar delivers accuracy to 0.5 mils, far more than

necessary for almost all tracking purposes, yet only a fraction of the cost of huge units which deliver more (but so often un-needed) accuracy. Since more down range

locations are possible with this reduced cost, the MPS-26 provides absolute protection against catastrophic failure. Here, then, is the economical yet positive answer to mobile missile range instrumentation — to the complete satisfaction of both the engineer and the budget officer. For our complete specifications, please write or telephone Canoga Electronics.

CANOGA



CANOGA ELECTRONICS CORPORATION VAN NUYS, CALIFORNIA FORT WALTON BEACH, FLORIDA

Circle Reader Service Card 29

SANDERS' EXPANSION ANNOUNCED

As the first step of a major facility expansion program totalling over \$2,000,000 Sanders Associates, Nashua, N. H. has arranged for outright purchase of new production and engineering facilities of 50,000 square feet in Plainview, Long Island. The expansion was announced by president Royden C. Sanders, Jr., in a report prepared for the annual stockholders' meeting.

At the same time he revealed the acquisition of a second plant in the "electronics belt" of eastern Massachusetts also is now under negotiation, and is expected to be completed shortly.

Additional expansion at the Nashua location of plant, personnel, and equipment will continue at a stepped-up pace at the same time, Mr. Sanders pointed out. Within a year that plant will be fully occupied in its 11 acres of floor space. Additional employees will continue to be added until it totals well over 2,000, and capacity estimates range from more than \$30,000,000 sales volume annually.

The two new plants will handle heavy increases in production and development contracts received in recent months and are expected to mount faster during the near future. They will give Sanders Associates capacity for a sales volume of \$40,000,000 annually.

Operations at the new Plainview plant are scheduled to start within 60 days, he said, and with new construction to be started immediately will occupy 50,000 square feet of plant space. Further enlargement to 100,000 square feet is tentatively scheduled for later. The imminent Massachusetts facility will be about the same size and can also be rapidly expanded.

— m w j —

HART NAMED MANAGER AT RCA

Edward J. Hart has been appointed manager of the Radio Corp. of America Microwave Department, according to J. J. Graham, Division vice president and general manager, RCA Communication and Control Division.

Mr. Hart, who joined RCA in 1953 as a microwave sales coordinator, received his electrical engineering degree at the University of Notre Dame. From 1942 to 1946, he served with the U. S. Signal Corps as a procurement officer for communications equipment.

Mr. Hart will report to F. J. Dunleavy, general manager, RCA Industrial Controls, who in turn reports to Mr. J. J. Graham. In his new post, Mr. Hart will supervise Microwave Marketing, Engineering and Special Projects.

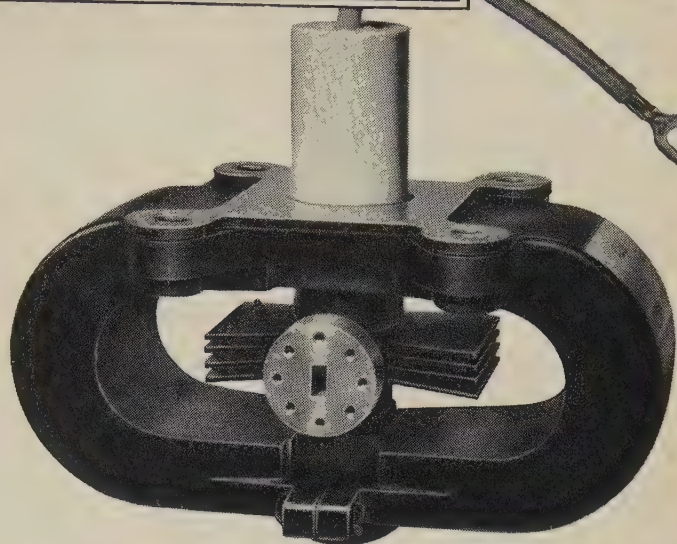
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(Continued on page 45)

the microwave journal



NEW



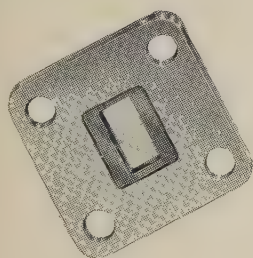
Sylvania's new XM-4218
3/5 actual size

Ka-band magnetron

rugged, lightweight, low in cost

Designed for missile and airborne applications... mapping, surveillance, drones, fire control... this 25 kilowatt Ka-band unit operates at 33,000 ft. without capsule pressurization or potting compound. Corona problems are eliminated by a unique new ceramic cathode support design. The tube withstands 10 G vibration (50 to 2000 cycles), and meets military environmental specifications. It is extremely light in weight (approx. 4 lbs.) making it one of the lightest-weight medium power Ka-band tubes. Engineering samples are available.

...with matching waveguide window



WG-4223
actual size 3/4" x 3/4"

Made to operate with the new Ka-band XM-4218 is WG-4223... 32 to 37 kmc... 50 kilowatt peak power and 1.10 VSWR. It withstands 35 psig.

This is one of 29 Sylvania waveguide windows covering frequencies from 2.6 to 37 kmc. Both glass and mica windows are available. In addition to existing units, new types can be designed to specific requirements for applications from

pressurized radar systems to microwave links.

• • •

For more information on these and other units in Sylvania's extensive line, wire or phone your nearest Sylvania tube sales office, or contact Sylvania Microwave Device Operations (formerly Special Tube Operations), 1891 East Third St., Williamsport, Pa.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**





WILL
THEY
REALLY

HAVE TO REWIRE PALO ALTO?

Here at Levinthal, just nine of the jobs currently in the plant, if all turned on at once, would pull 10 megawatts of average power from the a-c mains, enough for a small city. But don't worry, there's plenty of power in the West.

Shown in the picture is the fourth largest of the nine, a microwave-tube-test power supply and modulator for modulating-anode klystrons. Designed and built by Levinthal, it includes a number of advanced features for flexibility and safety.

Perhaps your problems include one requiring high powers with engineering and production pushing the state of the art. If so, Bob Johnson, our application-engineering manager, is the man to discuss your needs.

LEVINTHAL ELECTRONIC PRODUCTS

STANFORD INDUSTRIAL PARK PALO ALTO 7, CALIFORNIA
Circle Reader Service Card 31



SUBSIDIARY OF
RADIATION
INCORPORATED

(Continued from page 42)

SPERRY NAMES LEARNED AS MANAGER OF TUBE DIVISION



Appointment of Dr. Vincent R. Learned as manager of the Electronic Tube Division, Sperry Gyroscope Co., Great Neck, N. Y. was announced today by Carl A. Fricke, president.

Dr. Learned, formerly the division's chief engineer, has been in microwave technology for more than 20 years. In his new position he will direct the division's programs to discover, develop and make readily available advanced electron devices needed for improved capabilities in astronautical systems, radars, missiles, and other defense weapons.

Joining Sperry in 1943 as project engineer, Dr. Learned was active in the early development of carrier wave and pulse doppler radar systems using new microwave power klystrons. He later led development of the first multi-million watt klystron which made possible the modern "super powerful" radar.

The Sperry scientist received a BS degree in electrical engineering at the University of California in 1938 and a PhD degree at Stanford University in 1943. He holds six patents for inventions of radars and other microwave devices.

He is a fellow of the Institute of Radio Engineers and a member of the American Physical Society, Sigma Xi, Eta Kappa Nu and Tau Beta Pi.

— m w j —

PIERCE ELECTED TO CRESTMONT BOARD

Crestmont Consolidated Corp., San Marino, Cal., formerly Crestmont Oil Co., has announced the election of Cameron G. Pierce, president of Ling Electronics of Los Angeles, to the company's board of directors.

Pierce's election followed the disclosure recently of the company's entry into the electronics business. Crestmont now operates a Crestmont Electronics Division with facilities in Burbank, Cal.

— m w j —

(Continued on page 46)

December, 1960



BUSY BODY

NOW HERE'S A SWITCH! This Airtron-designed ferrite switch has an odd habit. Unlike most ferrite devices, which are known and respected for their non-reciprocal ways, this one looks the same from either end.*

Used for time-sharing between altitude and azimuth antennas of a GCA radar system, our subject switches both transmitted and received signals to and from each antenna. Switching is accomplished by reversing the current in the coil which biases one of the ferrites. This changes the phase shift in the associated ferrite section, and the signal path changes from one alternate route to the other.

SPECIFICATIONS OF NOTE:

PEAK POWER:	250 KW	INSERTION LOSS:	0.65 DB MAX
AVERAGE POWER:	300 W	VSWR DURING SWITCHING:	1.2 MAX
SWITCHING TIME:	10 mS		(terminated in matched load)
ISOLATION BETWEEN ARMS:	20 DB MIN	VSWR FULLY SWITCHED:	1.15 MAX
			(terminated in matched load)

Ferrite switches are one of a number of microwave devices currently on our manufacturing schedule. Others include ferrite isolators, dummy loads, flexible waveguide, and waveguide hardware. May we tell you more?

*We mean, of course, that it looks the same to an entering signal. Ourselves, we know that there's a dummy load attached to an arm on one end, none on the other.

AIRTRON

A DIVISION OF LITTON INDUSTRIES



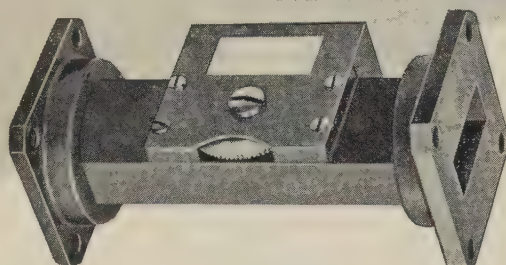
AIRTRON-MORRIS PLAINS • 200 EAST HANOVER AVENUE, MORRIS PLAINS, N. J.
GENERAL OFFICES AND ADVANCED DEVICES LABORATORIES, MORRIS PLAINS, N. J.

Circle Reader Service Card 32

NEW! MINIATURE LIGHTWEIGHT ATTENUATORS

X AND KU BAND ALUMINUM

3½ OZ. WEIGHT



TYPE 609-709

- SHIELDED
- RUGGED
- ACCURATE

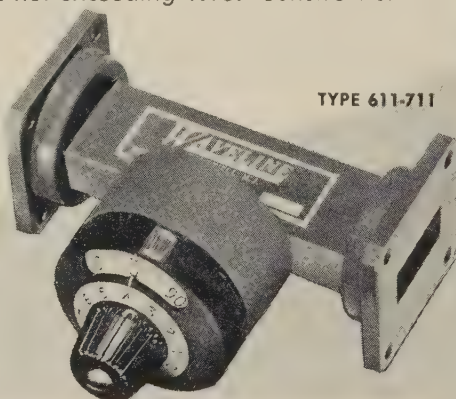
TYPE 609-709 are NEW — A small, lightweight, rugged, highly accurate attenuator designed to provide accurate settings under conditions of shock and vibration. The dial can be securely locked. Finish is Iridite. Weight 3½ ounces.

Excellent shielding properties, low 1.15 maximum VSWR value, 0.3 db. maximum insertion loss and a range of 30 db. combine to provide exceptional electrical operation in a small unit.

TYPES 611-711 — The attenuation range of these units is 35 db. calibrated at 9.60 and 15.0 Kmc/Sec. Maximum insertion loss is 0.3 db. with VSWRs not exceeding 1.15. Construction is brass, gold plated.

Calibrated
5.0 db points
centerband
frequencies

COMPLETE
CATALOG
AVAILABLE



TYPE 611-711

Type	Unit Price	Frequency Range Kmc/Sec	Attenuation Range	Waveguide Type	Length Inches
609	\$50.00	8.2-12.4	30 db	RG-67/U	3.50
709	50.00	12.4-18.0	30 db	RG-91/U-AL	3.50
611	75.00	8.2-12.4	35 db	RG-52/U	3.75
711	75.00	12.4-18.0	35 db	RG-52/U	4.00

LEADERS IN ATTENUATION DEVICES

WAVELINE INC.

CALDWELL, NEW JERSEY

Circle Reader Service Card 33

LFE NAMES NEW WEST COAST RE

The Instrument Division of Laborato for Electronics, Inc., Boston, Mass., h named O'Halloran Assoc. of Los Angel as its new West Coast sales representati organization.

According to Perry Pollins, divisio sales manager, O'Halloran Assoc. wi handle all of the LFE division's produ lines, which include ultra-stalide micro wave oscillators (Stalos), crystal locke klystron oscillators, microwave te instruments, and photo-etched microwav standard circuit modules.

O'Halloran Assoc. has sales offices i San Diego and San Francisco, Cal. i addition to its main office in Los Angele

— m w j —

LEWIS AND KAUFMAN ACQUIRES CASCADE RESEARCH

Lewis and Kaufman Electronics Corp Los Gatos, Cal., through a direct cas transaction, has acquired Cascade R search, which was a division of MonD gram Precision Industries, Inc.

Lewis and Kaufman, a producer o electron tubes, has, under new managemt, been expanding into the microwav tube and sub-systems fields. Acquisition of Cascade Research, a developer/manu facturer of microwave ferrite component will augment the microwave activities o L & K. In addition to microwave develop ment and production, L & K is engage in printed circuitry, through Printroni Corp., a subsidiary located in Palo Alto, Cal.

Cascade Research becomes the micro wave components division of Lewis an Kaufman, and will remain in its present location, in Los Angeles, Cal. Jerome S Jaffe, co-founder of the original Cascad Research Corporation, continues as Divi sion Manager. Herman Chait, formerl with the Naval Research Laboratory, remains as Chief Scientist. Clay Agadoni, formerly Assistant Chief Engineer, wil assume the position of Production Manager.

— m w j —

LITTON GAINS NEW PRODUCTION ENGINEER

Harold Lakin has joined the staff o Litton Industries' Electron Tube Division San Carlos, Cal., as a production enginee in the crossed field department.

Lakin has 11 years experience in th design, development and production o microwave tubes. He most recently wa head of fabrication design for Eitel-Mc Cullough, Inc. where he had been em ployed since June 1956.

Lakin is a 1949 graduate of Renssela Polytechnic Institute, Troy, N. Y., where he earned his Bachelor degree in Mechan ical Engineering. He also attended New York University and Stanford University

— m w j —

(Continued on page 48)

the microwave journal



Announcing...

wide range voltage-tunable magnetron from Eimac

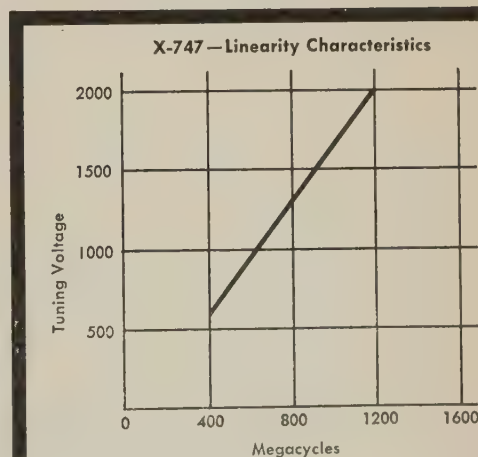
Take a look at the world's most advanced voltage-tunable magnetron: Eimac's new X-747, shown here with its magnet and cavity. This new tube can be tuned over the exceptional range of 400-1200 megacycles—a range approached by no other electronically tunable device. And it's extremely linear! Nominal output power of the X-747 is 100 milliwatts.

And too, the X-747 is easier to use than any similar device. No complicated heater voltage regulation is needed. Back heating is eliminated through its exclusive indirectly-heated matrix cathode plus advanced electron injection design. And heater power supply can be *either* AC or DC.

These advances make possible the most reliable voltage-tunable magnetron available today. Eimac can readily develop and produce other VTM types to meet *your* specific needs. For full information, write: Microwave Product Manager, Eitel-McCullough, Inc., San Carlos, California.

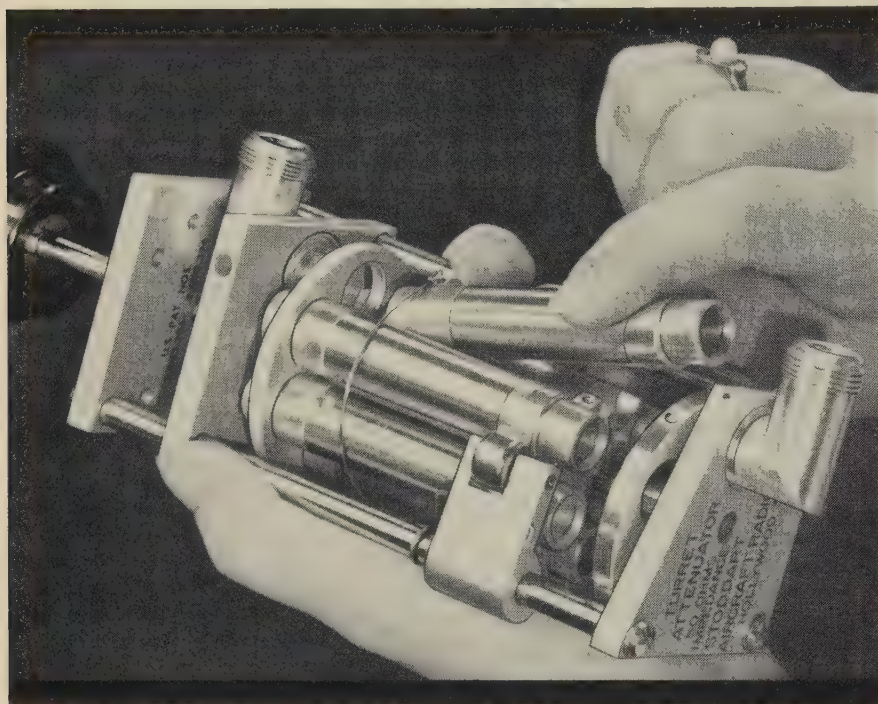
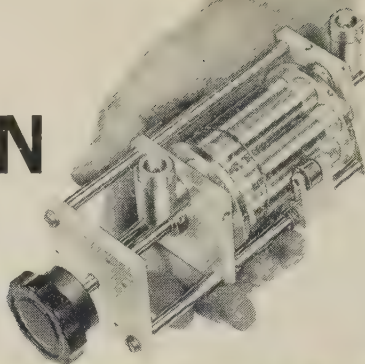


MICROWAVE TUBES • AMPLIFIER KLYSTRONS • NEGATIVE-GRID TUBES



Circle Reader Service Card 34

CHANGE db VALUES OF ATTENUATION IN SECONDS!



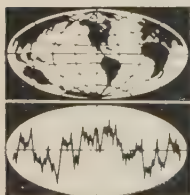
STODDART'S new turret attenuators* offer quick change of db combinations compatible to your system requirements.

Simply remove three set screws and the pad retainer ring moves forward for easy replacement, removal or rearrangement of pads.

NET BENEFITS TO USER . . .

- Easy pad replacement eliminates downtime otherwise required for unit or equipment dismantling.
- No increase in price!

*Patent applied for



STODDART

AIRCRAFT RADIO CO., INC.

6644 Santa Monica Blvd., Hollywood 38, Calif. HO 4-9292

serving 33 countries in radio interference control

16-page
UHF Attenuator
Catalog No. AT-3 gives
complete details and
specifications of new
Stoddart attenuators,
terminations and
turret-type step
attenuators.



Industry News

(Continued from page 46)

KEARFOTT MICROWAVE APPOINTS MARVIN J. BOCK



Marvin J. Bock has been named new chief engineer of the Kearfott Division, General Precision Inc., Van Nuys, Cal., manufacturers of precision microwave components and test equipment. The new assignment announcement was made by Willard A. Hughes, general manager, Kearfott Division, a subsidiary of General Precision Inc. Mr. Hughes announced that Mr. Bock will also head up the extensive Research and Development program for Microwave Products.

Mr. Bock has been active in the radar components field since 1941, having been associated with Raytheon since that time until his new affiliation with Kearfott in the spring of 1960. His work in the field has been in the development and manufacture of equipment for testing and evaluating magnetrons, klystrons and hard-glass tubes used in World War II radar equipment. He was also in charge of the Microwave Heating and Processing Laboratory developing diathermy and electronic cooking devices.

Prior to joining Kearfott, Mr. Bock was in charge of microwave sub-systems component, and antenna development of all countermeasures and radar activity for the Raytheon Santa Barbara Laboratory. These included such areas as lens antennas, ferrite devices, filters, detectors, microwave i-f mixers, and applications of traveling-wave and backward-wave oscillators.

Mr. Bock is a member of the IRE, holds a BS degree in Electrical Engineering, and has been awarded three patents in the fields of antenna and microwave design.

—mwj—

LFE MOVES WEST COAST OFFICES

Laboratory For Electronics, Inc., Boston, Mass., has moved its west coast regional offices from 211 South Beverly Dr., Beverly Hills, Cal., to 6310 West 89th St., Los Angeles 45, Cal., according to Nelson S. Praigg, regional marketing manager.

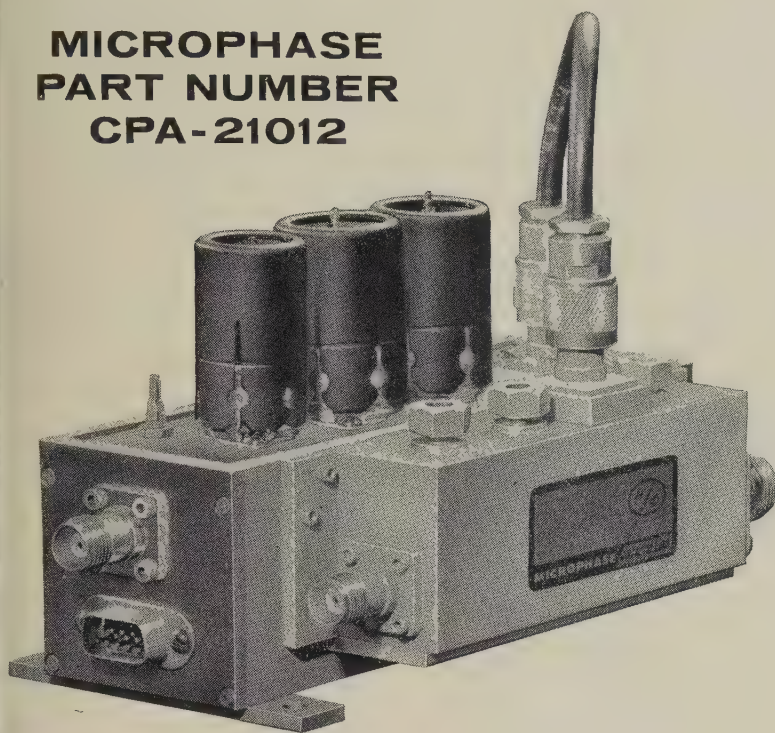
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(Continued on page 50)

the microwave journal

MC μ/ϕ Low-Noise Microwave Receiver Heads

MICROPHASE
PART NUMBER
CPA-21012

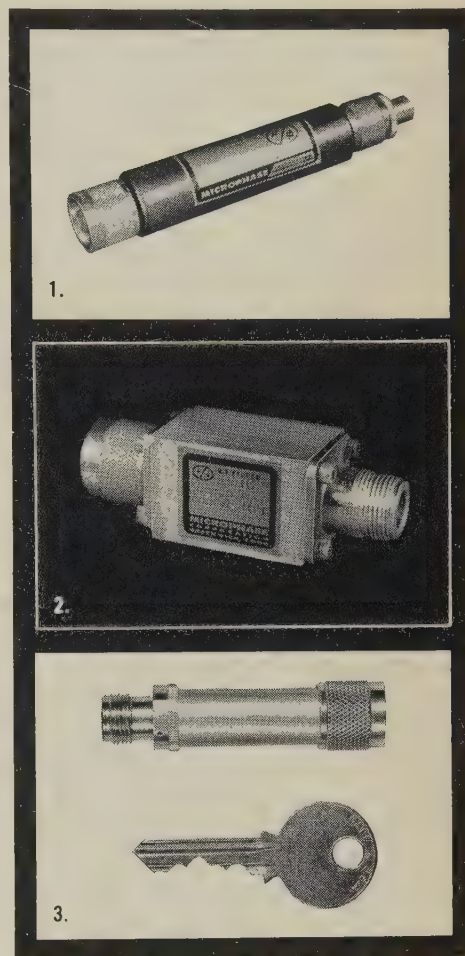


SPECIFICATIONS

Tunable Signal Band	1000-1200 mc
Input Selectivity ($f_0 \pm 100$ mc)	25 db
Input Bandwidth	10 mc
Input VSWR	1.6 max
LO Input VSWR	1.6 max
Overall Noise Figure	8.0 db
IF (30 mc) Bandwidth	6 mc
IF Gain	40 db
Crystal	1N21WE

Tunable filtering is an integral part of MICROPHASE Receiver Heads. By internally connecting the preselector to the mixer circuitry, the inherent phasing problem is avoided. This configuration results in a compact, sensitive, tunable Microwave Receiver Head.

Receiver Heads in different bands, with greater selectivity, are also available from MICROPHASE. Integrated packages offer the advantages of small size, light weight, and low cost without sacrifice of performance.

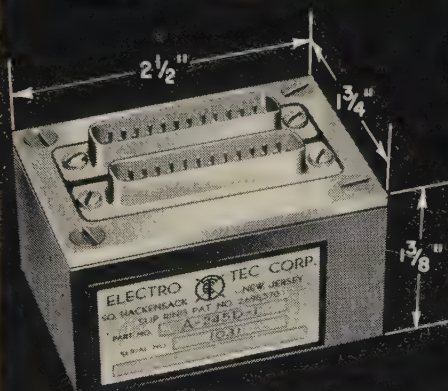


- 1. Compensated Detector Mount Model CDV-2510**— covers the 500-1000 mc band, with -60 dbm average tangential sensitivity. This unit is equipped with DC return and has an overall length of $5\frac{1}{4}$ inches including connectors. Octave Detector Mounts with comparable performances are also available in the L, S, and C Bands.
- 2. Harmonic Generator Model CUH-4-165** (shown without Harmonic-Suppression Filter). Input VSWR 1.5:1 max; conversion efficiency less than 25 db; frequency range 10% centered at 650 mc. In a typical arrangement, suppression of undesired harmonics by 60 db or greater is realized.
- 3. Miniature Low-Pass Harmonic Suppression Filter Model LP60-295.** Has less than 0.2 db insertion loss from DC to 750 mc; VSWR over this range is under 1.2:1. Stopband attenuation of 60 db is maintained up to 9000 mc. This Filter weighs under $1\frac{1}{2}$ ounces.

M I C R O P H A S E
C O R P O R A T I O N

Box 1166W Greenwich, Conn. NO 1-6200 WE 9-9190 TWX GNWICH CONN 759

A SIGNAL ACHIEVEMENT IN TELEMETRY... ELECTRO-TEC'S NEW 450-CIRCUIT COMMUTATING SWITCH



Electro-Tec's new compact 8-oz. motor driven telemetering switch enables circuit combinations up to a maximum of 5 poles, 90 channels per pole... truly the answer to precision performance with optimum size and weight.

Specifically developed for satellite and missile use, the ETC switch incorporates unique engineering ideas extending its utility to a variety of other military and industrial applications. Exclusive microminiature design minimizes brush velocity. Precious metal contact surfaces assure lowest levels of noise and resistance. Hermetically-sealed connectors add to environmental protection. These and other features provide a life expectancy of well beyond 1000 hours. Write for new ETC switch brochure.

ELECTRO-TEC CORP.

South Hackensack, N. J.
Blacksburg, Va.—Ormond Beach, Fla.

WEST COAST LICENSEE: PACIFIC SCIENTIFIC CO., P. O. BOX 22019, LOS ANGELES 22, CALIF., PAT. NO. 2,866,046

Circle Reader Service Card 37

Industry News

(Continued from page 48)

STRONG NAMED SENIOR APPLICATIONS ENGINEER

Appointment of Edson D. Strong as senior applications engineer of the Advanced Devices Laboratory of Airtron, division of Litton Industries, Beverly Hills, Cal., has been announced by Dr. Ernest Wantuch, laboratory director.

The laboratory is located at Airtron Morris Plains, N. J. facility.

Strong received his early schooling in West Haven, Conn. He is a graduate of Rahway, N. J., High School, and studied civil engineering at the University of Montana. He has spent eight years with Airtron, working in engineering positions including drafting supervisor, product designer in research and development, and project engineer on special assignment to Airtron's Microwave Components Group.

The Advanced Devices Laboratory is engaged in research furthering the state-of-the-art in the field of microwave components, solid-state materials and complex sub-systems.

— m w j —

LORAL FILLS SYSTEMS PLANNING POST

The appointment of Eugene Mogul as Manager, Systems Planning, Loral Electronics Corp., New York, N. Y., was announced by the company recently.

Mr. Mogul's responsibility encompasses market planning and coordination for the company's advanced military electronic systems. Previously marketing and sales manager, Inertial Switch, Inc., he has also been associated with Arma, CBS Laboratories and Emerson Radio, in sales, administrative and engineering positions.

Mr. Mogul holds a BSEE degree from Columbia University and has also studied at Harvard University and M.I.T.

— m w j —

WALTER NAMED MENLO PARK SALES MANAGER

Menlo Park Engineering, Menlo Park, Cal., has appointed Charles Walter as sales manager, according to Harold W. Harrison, president of the microwave instrumentation firm.

Mr. Walter will assume complete responsibility for marketing of the firm's traveling-wave amplifiers, electronically swept oscillators, power leveling systems and solenoids for traveling wave tubes and backward wave oscillators. His duties will also include responsibility for broadening the product line of microwave instrumentation produced by the firm.

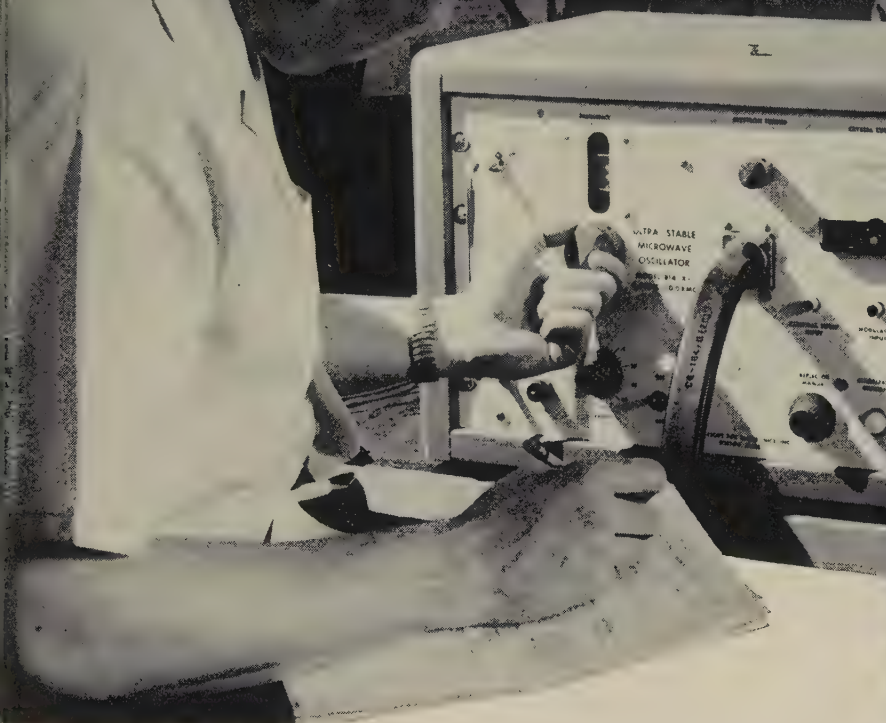
A graduate of the University of California, Mr. Walter was manager of applications engineering for Granger Associates of Palo Alto for the past 18 months. Prior to that he was Sales Manager of Sierra Electronic Corp. for five years. Mr. Walter is a member of the IRE and an associate member of AIEE.

— m w j —

(Continued on page 52)

the microwave journal

Where stability and power count . . .



If you have an application where stability and power output requirements are *really* exacting (production or testing of microwave components of air defense missile systems, for example), it's to your advantage to investigate LFE Series 814 Microwave Oscillators. They have been tried and proven in all fields of microwave work over a period of 7 years.

STABILITY — Series 814 Oscillators are ultra-stable. Average short term frequency stability (residual) is five parts in 10^8 . Average long-term stability is one part in 10^6 . A self-contained invar dual mode reference cavity and AFC loop insures this performance. When a frequency is selected via the reference cavity, and the Klystron locked to it, stability characteristics conform to the above specifications. Klystron is conveniently locked by observing a stabilization indicator light bringing about great ease in operation.

POWER — The table on the right tells the power story. Nominal powers available in standard Series 814 Oscillators range from 20 to 500 milliwatts. Outputs up to 1.5 watts are available on special order.

SPECTRUM COVERAGE — Series 814 is a complete line, covering the microwave spectrum from 2500 to 26,000 megacycles.

AMPLITUDE MODULATION — Up to 15% by internal 1 kc oscillator, jack on front panel for external modulation.

FREQUENCY MODULATION — Deviation up to 0.01% of selected frequency via external connector.



INSTRUMENT DIVISION

LABORATORY FOR ELECTRONICS, INC.

714 BEACON STREET • BOSTON 15, MASSACHUSETTS

WESTERN REGIONAL OFFICE, 211 South Beverly Drive, Beverly Hills, California.

SERIES 814 STANDARD MICROWAVE OSCILLATOR LINE

Oscillator	Frequency in mc/s	Nominal Power (milliwatts)
S-BAND		
814-S-1	2500-3050	75
814-S-2	2950-3600	80
814-S-3	4200-4800	70
C-BAND		
814-C-1	5100-5900	60
814-C-2	5800-6600	65
814-C-3	6300-7125	55
814-C-4	7125-8125	80
814-C-5	7500-8500	90
814-C-11	5700-6300	200
814-C-12	6200-6900	250
814-C-13	6800-7400	300
X-BAND		
814-X-1	8500-10,000	80
814-X-2	9000-10,500	55
814-X-3	9800-11,200	70
814-X-4	10,500-11,700	80
814-X-21	8500-10,000	500
K-BAND		
814-K-1	13,000-14,000	20
814-K-2	16,000-17,000	40
814-K-11	12,000-13,800	85
814-K-12	14,000-16,000	25
814-K-13	15,500-17,500	30
814-K-21	12,800-14,500	100
817-K-25	24,000-26,000	30

SPECIAL *Motor-driven* ROTARY SWITCHES

for

Telemetry
Sampling
Computers
Comparison
systems
Remote controls
Multiplexing
Radar
display

— in fact, wherever high-speed,
precise multi-circuit switching
in complex electric and electronic
circuits is required.

ELECTRO SWITCH designs and builds to your performance specifications — and to meet severe environments and MIL-spec requirements — special rotary switches that range from sub-miniature, dry-circuit selectors to heavy-duty, power-handling commutators.

Typical performance of special motor-driven rotary switch



3 poles; 30 positions per pole; non-shorting
Duty cycle: pole 1 — 78%; poles 2 & 3 — 53%
Life: more than 35,000,000 rotations at 1 ma 100 volts d-c
Insulation resistance: 100 megohms
Angular accuracy: 1/4 degree
Designed to meet applicable MIL specifications



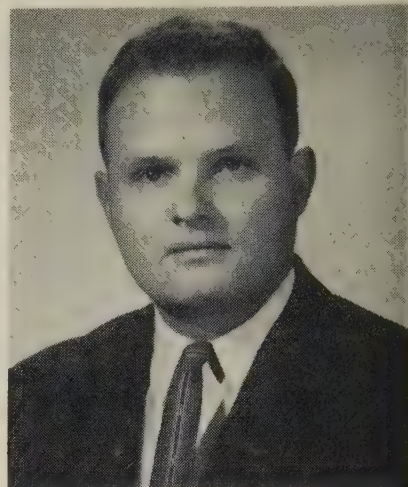
Write for our data form and check list to
use in specifying special rotary switches.

ELECTRO SWITCH
SLIP-RING DIVISION CORP.
Osterville, Massachusetts

Industry News

(Continued from page 50)

GRANGER PROMOTES BALLARD



The advancement of John W. Ballard to the post of manager of application engineering at Granger Associates, Palo Alto, Cal. has been announced by Dr. John V. N. Granger, president.

Dr. Granger said Ballard will assume wider responsibilities for the promotion of company programs in specialized electronic equipment and systems development. Ballard has been with Granger Associates since last winter on the applications engineering staff.

A native of Denver, Colo., Ballard attended Dartmouth College with a Holloway Naval Scholarship. He received his AB cum laude and an MS in Electrical Engineering and Business Administration in 1956 (as first in his class of engineering-business graduates students).

During a following period of service with the U.S. Navy, Ballard was an electronics officer at the South Weymouth Naval Air Station and took flight training at Pensacola, Fla. He had foreign duty in Japan, as electronics officer of an Electronic Countermeasures squadron. There he was responsible for the development, installation and testing of ECM systems and for the supervision of a corps of more than 100 technicians. He joined Granger upon separating from the service in San Francisco last December.

— m w j —

DR. STRAKER APPOINTED MANAGER AT MARCONI

Dr. T. W. Straker, has been appointed Deputy Manager of the Marconi Co.'s Radar Division, Chelmsford, Essex, England.

Dr. Straker joined the Marconi Co. in 1957. In 1959 he was appointed Chief of Projects Co-ordination Group, Research Division, at the Marconi Research and Development Laboratories at Great Baddow which post he held until his present appointment.

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(Continued on page 108)

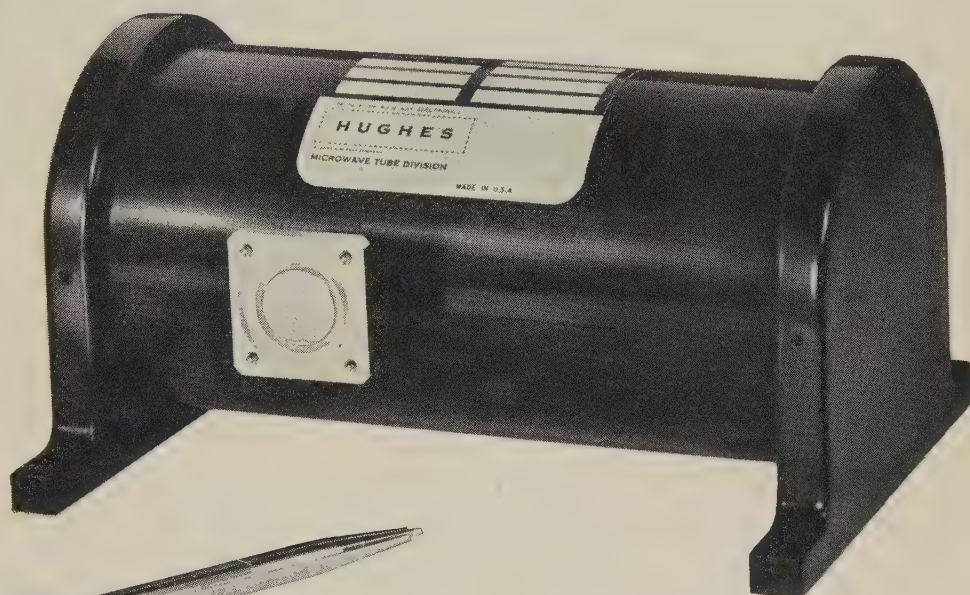
the microwave journal

HUGHES LINE OF K_u-BAND BWO's

Hughes K_u-band backward-wave oscillators are all permanent-magnet tubes with the compact, light-weight Hughes design that has proved so reliable. They are ideally suited for use in microwave signal and sweep generators, panoramic receivers, spectrum analyzers, frequency scan and navigational radars and countermeasures equipment. They feature low spurious output and narrow spectrum width. They are designed to give you thousands of hours of trouble-free life.

The new 326H, shown here, is of particular interest. It is specifically designed for use in test equipment and other strictly commercial instrumentation—and priced for that market. It is a small, streamlined tube with excellent operating characteristics.

All the tubes shown here are production products. Hughes will ship to meet your immediate requirements. For prices and full particulars, write today to Hughes Microwave Tube Division, 11105 Anza Avenue, Los Angeles 45, California.

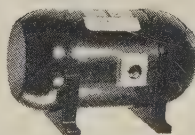


CREATING A NEW WORLD WITH ELECTRONICS

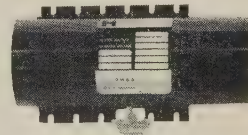
HUGHES

HUGHES AIRCRAFT COMPANY
MICROWAVE TUBE DIVISION

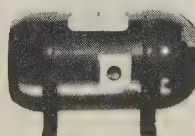
THE 326H For commercial applications. Minimum output: 10 mw over 12.4 to 18 kmc band with power rising to 65 mw in the center of the band. Like all Hughes BWO's, the Hughes 326H requires no external cooling. All electrodes are isolated from each other and from the case.



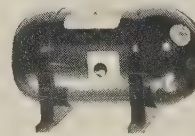
THE 315H Covers the entire K_u band. Average power: 50 mw. Frequency range: 15.8-17.2 kmc. Total weight of tube and magnet: 11.5 lbs.



THE 316H Full band. Average power: 10-60 mw. Frequency range: 12.4-18.0 kmc. Total weight of tube and magnet: 11.5 lbs.

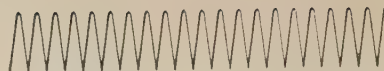


THE 317H Average power: 60 mw. Frequency range: 13.5-15.5 kmc. Total wt., tube and magnet: 10 lbs.

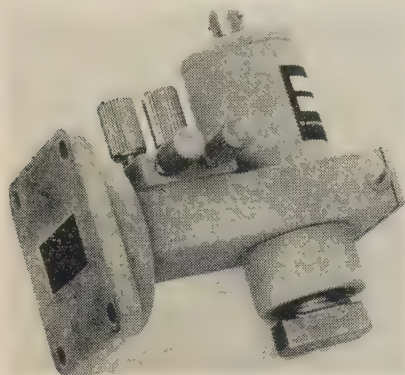


THE 318H Average power: 30 mw. Frequency range: 17.5-19.5 kmc. Total wt., tube and magnet: 10 lbs.

New Products



NEW MICROWAVE COMPONENT INTRODUCED



Radar Design Corp., Syracuse, N.Y., has introduced a new microwave component, the model 738 Tunable Crystal Mount. It is designed for ceramic crystals such as the IN23 series, and will mount any type of detector dimensionally similar to the IN23 series. With a crystal, or other detector mounted, the Model 738 can be tuned to present a VSWR of 1.1 or less at any frequency in the range 8.2 to 12.4 kmc by means of two tuning screws which can be locked if desired. The detector output connector is a female MB series connector.

Circle Reader Service Card 101

— m w j —

NEW LOW-COST MICROWAVE RELAY LINK ANNOUNCED

Electronic Systems, a Division of Mechanical Products, Inc., Jackson, Mich., has announced a new low-cost microwave relay link with a baseband width of five mc., power output of 0.1 watt, and operating in the 10,500 to 13,200 megacycle range for point-to-point FM transmission of television signals, one way voice communications channels and data channels.

The small size, portability and low cost of only \$4,490.00 for the complete system indicate its wide-spread use in linking scattered offices, permitting the economical transmission of closed circuit television pictures, computer data, remote control functions and telemetering information as well as its general use in the communications industry proper.

The Transmitter and Receiver for the new link are each self-contained in individual units weighing 31 and 32 lbs. respectively with no need for separate control units or power supply. The 420A System is portable and may be mounted on tripod, pedestal or other suitable base and includes both Transmitter and Receiver in Portable Carrying Cases, a Variable Cavity Wavemeter for use with both Transmitter and Receiver and two Power Cables.

The 420AR rack-mounted version is

identical to the 420A except for substitution of a rack mounting assembly for the portable cases.

In the 420A System the Parabola mount is self-contained on the case, eliminating any need for an additional mounting ring. Cases are completely weatherproofed and entire chassis is removable without removing parabola or case positioning. Both units incorporate identical "ruggedized" Eimac klystrons for operation under adverse conditions.

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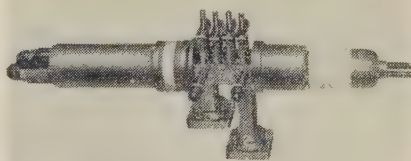
— m w j —

NEW VARIAN TUBE OFFERS HIGH CW POWER AT X-BAND

High CW power at X-band is available in the new VA 849 series of amplifier klystrons announced by Varian Associates, Palo Alto, Cal.

The new tubes are rated at 20 kilowatts, cover a frequency range of 7.125 to 8.5 kilomegacycles, and are tunable over a 60 megacycle range. The VA 849 four-cavity tubes have been tested to more than 25 kilowatts. The series was designed for applications requiring very low AM and FM residual noise.

Tuned for high efficiency the power gain is 37 db and the bandwidth is a minimum of 30 megacycles. The synchronously tuned power gain and bandwidth are 53 db and 15 megacycles respectively. Tubes are focused electromag-



netically, are self-centering in the focusing electromagnet and no critical focusing adjustments are necessary.

The new VA 849 tubes will have important applications in repeater satellites, moon-bounce signalling, radio astronomy and reflections from clouds of tiny orbiting needles. Other applications include CW radar and illuminator service.

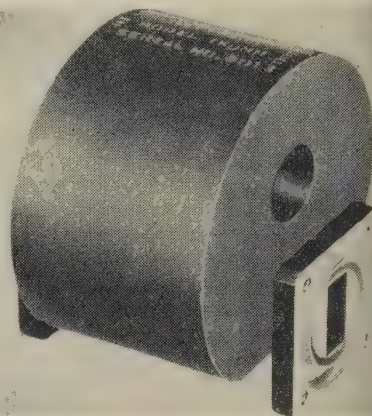
Circle Reader Service Card 103

— m w j —

RAYTHEON INTRODUCES NEW KU-BAND ISOLATOR

A new Ku-band Isolator fully tested for high power handling capabilities of 135 kw peak and 100 watts average has been introduced by Raytheon Co.'s Special Microwave Device Operations, Waltham, Mass.

Model IKuH8, only 2.44 inches long covers frequencies in the Ku-band region from 16,000 to 17,000 megacycles. Insertion



tion loss is .3 db maximum with isolation of 13 db minimum and 20 db maximum. VSWR is 1.06 maximum.

The new isolator, weighing only 11 lbs., is equipped with choke type UG 541/U flanges and RG-91/U waveguide. Delivery is 6 to 8 weeks from date of order.

Circle Reader Service Card 104

— m w j —

NARDA ANNOUNCES BROADBAND WAVEGUIDE FERRITE ISOLATORS

A new line of broadband waveguide ferrite isolators with a front-to-back ratio equal to any units on the market today has been introduced by the Narda Microwave Corp., Mineola, L. I., N. Y. Minimizing the efforts of microwave system load mismatches upon signal sources, these new Narda Isolators are specifically designed for maximum load isolation with minimum insertion loss over full standard waveguide frequency ranges.

This type of broadband ferrite isolator is extremely useful for maintaining signal source stability, and eliminating long line and frequency pulling effects in all types of low power microwave signal sources.

Isolation is 20 db minimum in C Band (3.95 to 5.85 kmc.) and X_N Band (5.4 to 8.2 kmc.); it is 30 db minimum in X_B Band (7.05 to 10.0 kmc.) and X Band (8.2 to 12.4 kmc.). Insertion loss is 0.75, 0.7, 0.5, and 1.0 db maximum in these respective bands. As a result, the minimum front-to-back ratio ranges from 26 to one in C Band to 60 to one in X_B Band.

The four models of waveguide isolator are priced from \$220.00 to \$250.00 and are available from stock.

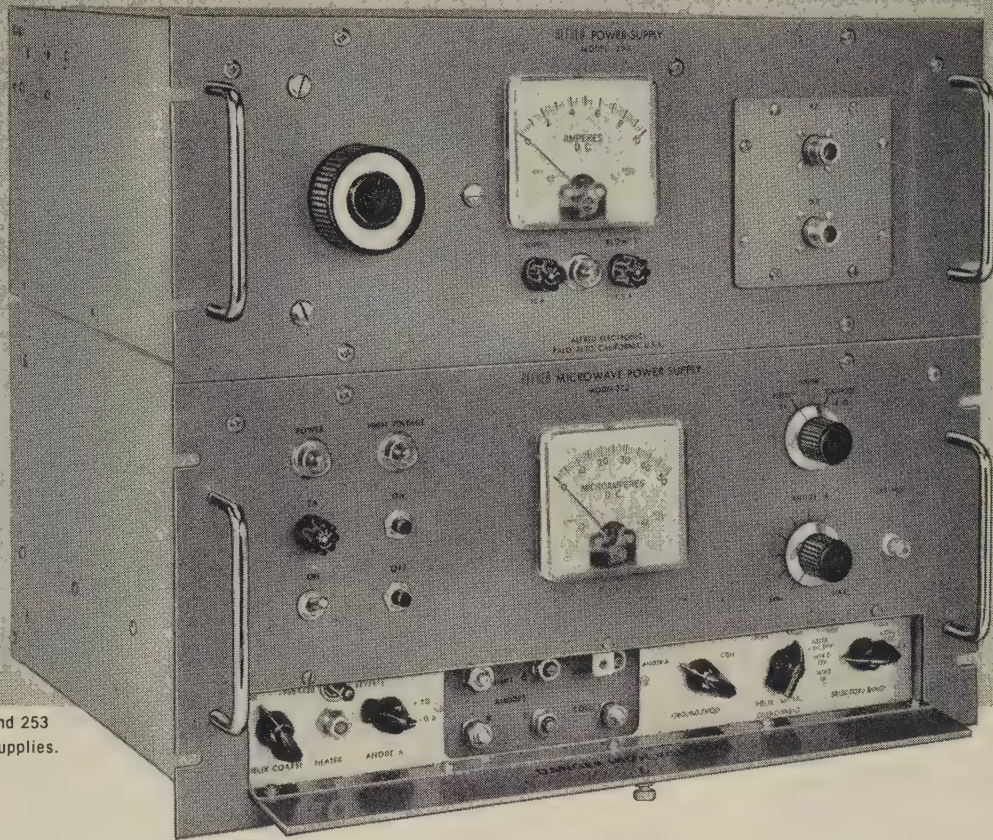
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— m w j —

(Continued on page 56)

the microwave journal

Power low noise figure TW tubes



Alfred Model 252 and 253
Microwave Power Supplies.

with one ALFRED supply!

This compact ALFRED ELECTRONICS microwave power supply provides electrode voltages for nearly all medium and low noise figure TW tubes. Companion solenoid supplies for electromagnet focused TW tubes are available. Here are the major advantages of this precision ALFRED supply:

☆ FLEXIBILITY

One electrode supply operates most presently known tubes. It will operate new tubes as they become available. Cover present and future needs with *same* supply.

☆ INTERCHANGEABILITY

Build all your low noise amplifiers around standard unit. Simplify servicing. Stock parts for only one type of supply.

☆ LOCAL OR REMOTE OPERATION

Model 252 design permits remote operation of TW tube as may be required with broad-band preamplifiers. Heater supply has extra wide voltage range to compensate for cable IR drop.

☆ SIMPLE OPERATION

Only two controls on front panel for day-to-day operation. Set-up controls are on recessed subpanel. All voltages and currents are internally measured using front panel meter and recessed selector switch.

☆ STABILITY

Electrode supplies are well-regulated and designed for minimum drift. Use of dc heater power reduces spurious amplitude modulation.

☆ 50 TO 450 CPS INPUT

Wide band power input permits use with almost any available power source.

☆ ECONOMY

Separate solenoid supplies are available. Purchase only the supply you need when you need it.

KEY SPECIFICATIONS FOR MODEL 252

Helix: Voltage, 75 to 1400 v; Ripple, less than 20 mv pk-to-pk; Regulation, $\pm .03\%$ line. Collector: 0 to +300 v relative to helix. Four Anodes, ranging from -100 v to +900 v relative to cathode. Heater, 0 to 11 v DC at 0 to 1 amp with 2% regulation. All electrode supplies internally metered.

Two low ripple Solenoid Supplies are available. Both are adjustable over a wide range providing adequate power for most TW tube focusing magnets. Model 253 is unregulated; Model 254 is current regulated.

KEY SPECIFICATIONS FOR MODEL 253

0 to 105 v DC at 0 to 7.5 amp or 0 to 110 v at 6 amp. Ripple, .5% pk-to-pk.

KEY SPECIFICATIONS FOR MODEL 254

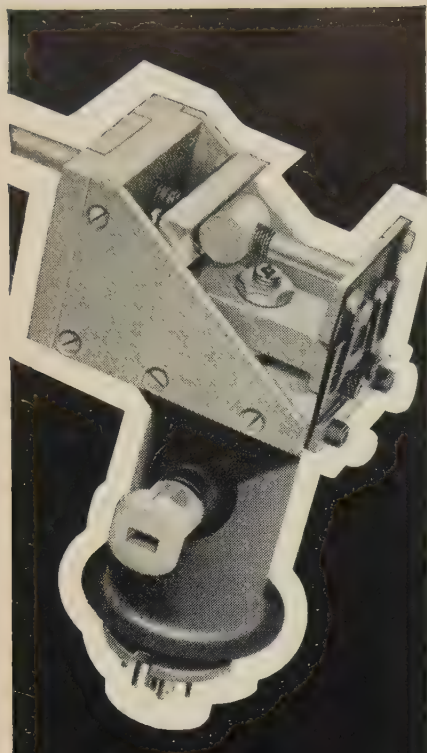
0 to 100 v DC at 0 to 7.5 amp or 0 to 105 v at 6 amps. Ripple, .5% Regulation, $\pm 1\%$ for $\pm 10\%$ line change or 30% load change.

PRICES: Model 252, \$890; Model 253, \$200; Model 254, \$350.

WRITE FOR MORE DATA—Contact your ALFRED engineering representative for more details, or write us directly at Dept 69.

ALFRED ELECTRONICS

897 Commercial Street • Palo Alto, California
DAvenport 6-6496



E.M.I. Q-BAND REFLEX KLYSTRONS

Five high voltage, integral cavity types, with improved plate tuner for good frequency stability and freedom from microphony.

Type No.	Approx. f. range KMc/s	Min. Power (mW)	I_A (mA) (at $V_A=2KV$)
R9521	35-40	15	12
R5146	34.2-35.6	30	10
R9546	32-38	15	12
R9518	28-32	15	12
R9547	24-28	15	12

Average electronic tuning range of above, 60 Mc/s; WG22 waveguide termination.

...AND A NEW K-BAND KLYSTRON:

with similar external dimensions and tuner to R9546:

R9602	22-26	15
-------	-------	----

Average electronic tuning range, 40 Mc/s; WG20 waveguide termination.

The extensive range of EMI special tubes includes: plug-in klystrons & cavities, photo-multipliers, camera & C.R. tubes.



**E.M.I.
ELECTRONICS
LIMITED**

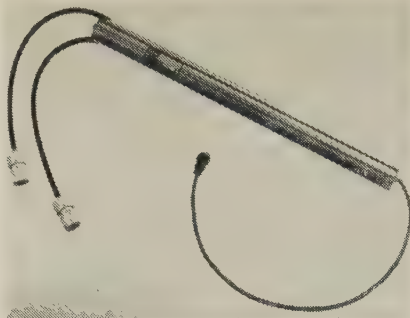
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HOFFMAN ELECTRON TUBE CORPORATION
804 NEWBRIDGE AVE. WESTBURY, L.I., N.Y. Tel: EDgewood 3-6650

New Products

(Continued from page 54)

HUGGINS ADDS NEW LOW NOISE TWT



Another addition to the line of low noise traveling-wave tube amplifiers manufactured by Huggins Laboratories, Sunnyvale, California, is the HA-76. The tube is solenoid focused and operates in the S-band at 2.3 to 2.9 kmc with a maximum noise figure of six db. Small-signal gain is 30 db minimum, and saturation power output is 0 dbm minimum.

The HA-76, without solenoid, weighs 1-1/2 lb. and measures one inch in diameter and 22-1/2 inches long.

Circle Reader Service Card 106

— m w j —

SPERRY ANNOUNCES AVAILABILITY OF GARNET MATERIALS

Sperry Microwave Electronics Co., Clearwater, Fla. announces the development of a series of Yttrium-Gadolinium Garnets for use in low frequency and/or extreme temperature applications. These materials are also particularly applicable in high average power applications and, under certain conditions, in high peak power applications. They have been used most effectively in the frequency range from 350 to 3,000 mc/s, from temperatures of $-65^{\circ}C$ to $+125^{\circ}C$, and at power levels from a few milliwatts to megawatt levels. In some applications they have been used at high average power levels.

Particularly useful applications for the materials are in very low frequency devices where very narrow linewidths are desired, such as in three-port circulators, and in the region from slightly above 500 mc up to and including X-band frequencies where a high degree of temperature stability is required under very high average power operating conditions.

The materials are available in a series of five different compositions whose four πM_s varies from 1750 to 750 gauss, whose linewidth varies from 50-225 oersteds, and whose temperature sensitivity varies from nominal to almost complete temperature stability depending upon the application.

Circle Reader Service Card 107

— m w j —

(Continued on page 57)

Think Backward

You need think back only a few years to cover the entire history of the backward wave oscillator. The first commercial BWO was made 8 years ago by Stewart Engineering Corporation... and was followed soon after by a family of backward wave oscillator tubes noted for exceptional performance characteristics.

It's not surprising that Stewart backward wave oscillators are guaranteed for a minimum of 500 hours — and characteristically outlive their guarantees — when you see the fantastic care and precision with which they are manufactured. Nor is it any wonder why their specifications are predictable, closely reproducible, and highly reliable.



Stewart Type OD 1-2 backward wave oscillator. Power output 50-250mw over the 1-2 kmc frequency range.

Thinking ahead, your files will be much more complete after you've received our new brochure and specification sheets covering BWOs from 1 to 18 kmc. We'll also be happy to provide you with details on custom-engineered tubes with special frequency, power output, voltage, and current specifications. Write today.

**STEWART
ENGINEERING
CORPORATION**

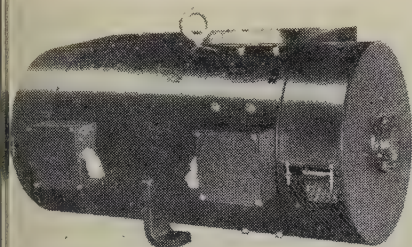


SANTA CRUZ · CALIF.

Circle Reader Service Card 48

(Continued from page 56)

UNINTERRUPTED POWER SYSTEM ANNOUNCED



Electric Specialty Co., Stamford, Conn. announces the selection of one of its Series 705 three-unit Uninterrupted Power Sets as relay station power supplies. To be used as the power-supply system in remote locations or at unattended microwave-link sites, the Uninterrupted Power Set will assure operation of the microwave relay, in the event of power-line failure, until such time as power is restored. Series 705 Uninterrupted Power Sets are particularly suited to military ground installations, aeronautical ground sites, computer installations and wherever power-line failure cannot be allowed to result in even momentary interruptions.

The system, designed for efficiency, compactness, and reliability, consists of a 7.5 hp AC motor driving a 6.5 kva

alternator to which is also coupled an 8.5 hp DC motor. The DC motor field is excited by the alternator and a special lifting mechanism holds the brushes away from the commutator in normal operation to eliminate brush wear. In the event of power-line failure, the DC motor is fed by a standby battery supply, the brushes are permitted to contact the commutator and the alternator is driven continuing to supply power until an auxiliary DC source is connected or the power-line failure is corrected.

Transfer from AC to DC drive occurs in less than 0.2 seconds and frequency is held within five per cent with full rated load on the alternator. ESCO's Series 705 Uninterrupted Power Sets are available in a variety of models using permanent magnet and trans-diode alternators from 2.5 to 30 kva or up to 25 kw in DC output systems. Some models use gasoline or diesel back-up motor-generator sets in place of battery supplies, and some are available which incorporate a battery charging circuit permitting charging when in normal operation.

Circle Reader Service Card 108

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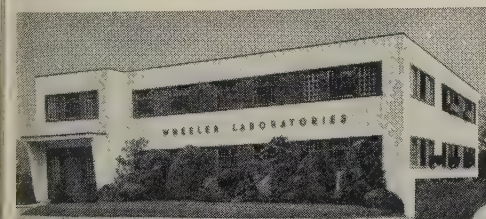
(Continued on page 91)

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

WHEELER LABORATORIES, INC.

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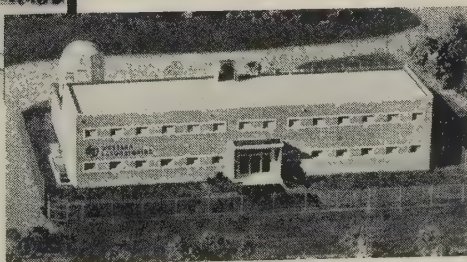


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Great Neck, New York

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WEINSCHEL

COAXIAL TERMINATIONS

DC to 10 KMC
50 ohms

Connectors: N, C, SC, BNC and TNC
Individual VSWR calibrations supplied at seven frequencies: DC, .4, 1, 2, 4, 7.5 and 10 KMC.

Made with Weinschel Film Resistors for maximum stability.



Type N
Connector

535-MN



535-FN



Type BNC
Connector

535-MB



535-FB



Type TNC
Connector

535-MT



535-FT



Type C
Connector

535-MC



535-FC

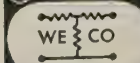


Type SC
Connector

535-MSC



535-FSC



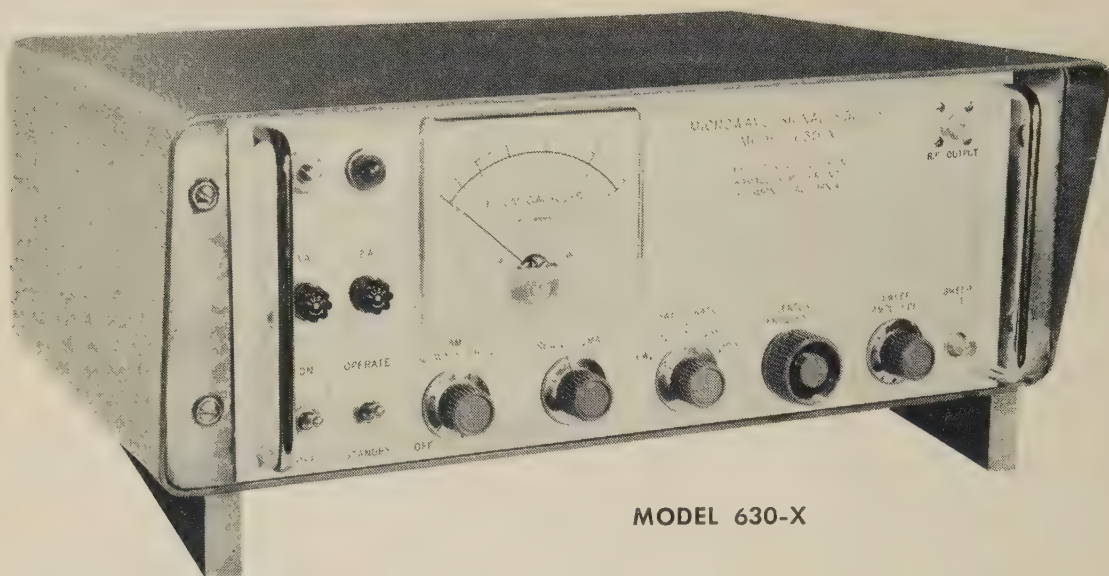
Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog.

Weinschel Engineering
KENSINGTON, MARYLAND

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A NEW

ELECTRONICALLY SWEEPED SIGNAL SOURCE



MODEL 630-X

WAVE PARTICLE offers a complete line of electronically swept microwave signal sources which cover the entire frequency range from 0.98 to 75.0 KMC. Uniquely engineered and designed, the instruments combine truly remarkable features that satisfy the most demanding requirements.

MODEL 630-X

8.2 - 12.4 KMC

Power Output . . .	20 mw. (minimum)
Sweep Rate . . .	C.W. or 0.1-100 CPS
Sweep Width . . .	A Few MC. to 4.2 KMC
A.M. Modulation . . .	800-1200 CPS Square Wave
Sweep Output . . .	Linear Sawtooth
Oscillator . . .	Varian VA-161
Price	\$2,850.00
Delivery	2-4 weeks

- ▶ **LIGHT WEIGHT, ONLY 28 LBS.**
- ▶ **SIMPLE TO OPERATE. A MINIMUM OF CONTROLS SIMPLIFIES OPERATING PROCEDURE**
- ▶ **COMPACT DESIGN. ONLY 7" x 19" PANEL AREA.**

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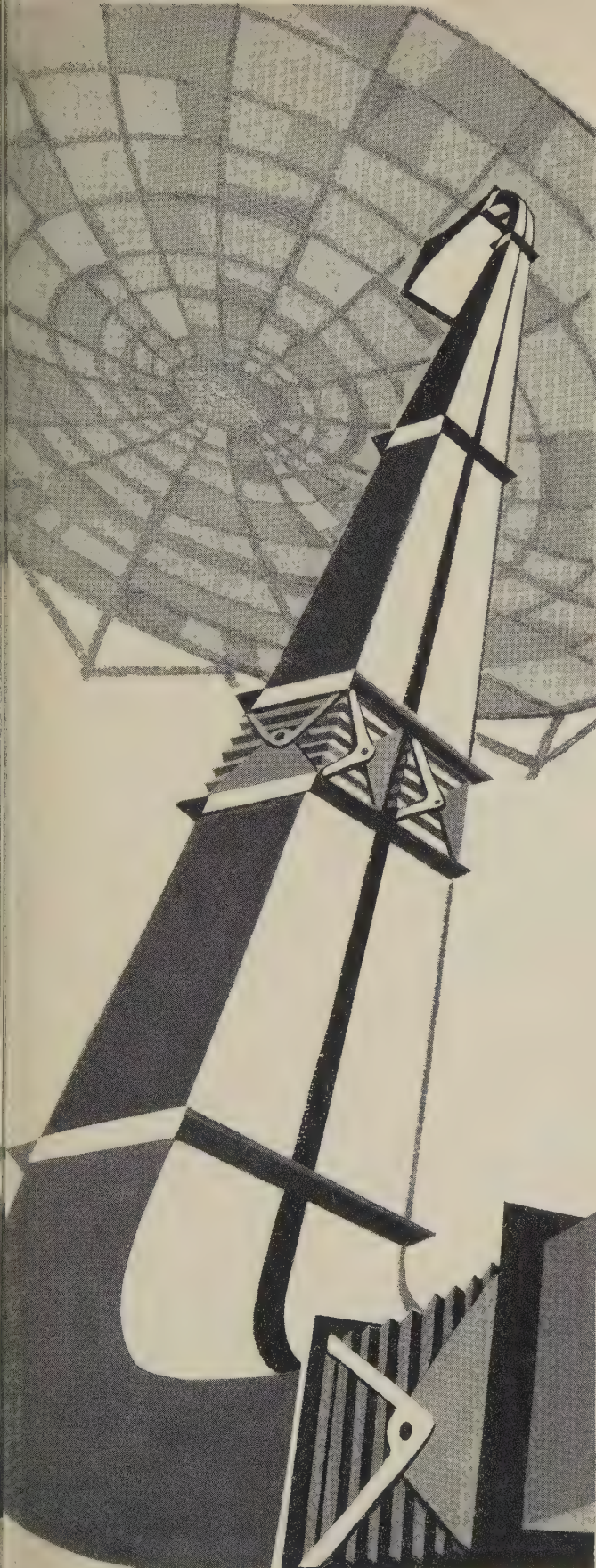
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Another breakthrough from I-T-E . . .

ARTICULATED WAVEGUIDE SYSTEM

Low Reflection Troposcatter Antenna Feed System for Greatly Improved Performance

Adding another engineering breakthrough to its fast growing list of accomplishments in the field of antenna system design and construction, I-T-E's Special Products Division announces an "Articulated Waveguide System" for Troposcatter. Now coupled to its high performance dual polarized TWINTEE feed horn, I-T-E offers completely new and improved articulated waveguide systems.

This achievement marks a new state of the art to meet the demands of high efficiency troposcatter. By a unique system design approach using pre-matched minimum length flexguide sections in conjunction with precision tolerance rigid waveguide, an extremely low VSWR is obtained, with generous allowance for mechanical adjustment.

Investigate these advantages:

- Lower VSWR
- Lower intermodulation effect
- Easier to support and install
- More rugged and serviceable
- All light weight aluminum

Write today for our large waveguide catalog.

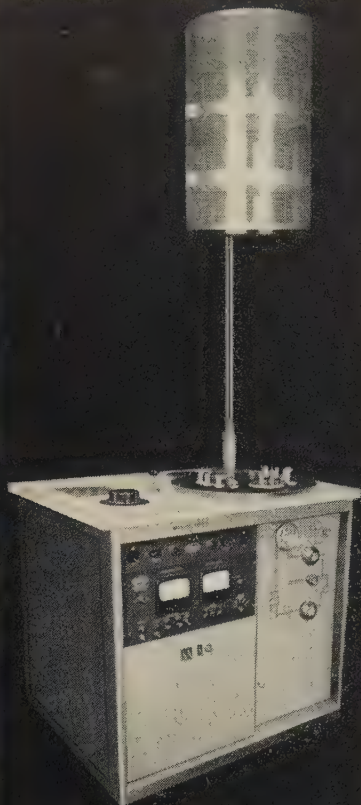


I-T-E CIRCUIT BREAKER COMPANY

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QUALITY
WITHOUT COMPROMISE



5×10^{-6} mm Hg
in 45 sec.

4" VACUUM SYSTEMS and COMPONENTS

VEECO's 4" high vacuum systems and components provide new freedom in vacuum engineering. Modular engineering of the "400" series permits you to purchase any of VEECO's matching components, individually or in groups, to form a vacuum system specifically suited to your needs.

VEECO manufactures a complete line of high vacuum equipment...Components, Leak Detectors, Evaporators, Systems...accepted as the quality line for over a decade.

For "400" Brochure or Complete Catalog, write Department 86B.



VACUUM-ELECTRONICS CORP.

Terminal Drive, Plainview, L. I. N. Y.

HIGH VACUUM & LEAK DETECTION EQUIPMENT

ANNUAL CUMULATIVE INDEX

the microwave journal,

January, 1960 — December, 1960

Volume III

The first index lists authors alphabetically and includes cross-indexing in the case of articles with multiple authors. The second index lists articles by subject categories. This is followed by a listing of Biographies, Company Profiles and Editorials (by author).

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Etkin, V. S., See: Aleksandrov, N. V. Forward, Robert L., and Frances Richey, "Effects of External Noise on Radar Performance," Vol. III, No. 12, P. 73.

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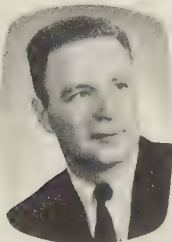
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MILTON MAGID

BSEE University of California, 1949; MSEE, UCLA, 1957. Head, Microwave Section, Primary Standards Laboratory, Hughes Aircraft Co; Head, Microwave Product Engineering, FXR, Inc.



RICHARD J. MOHR

BSEE, City College of New York, 1952; MSEE Polytechnic Institute of Brooklyn, 1957. Section Head, Microwave Components, FXR, Inc.; Project Engineer, Airborne Instruments Laboratory.



HUGO D. RITUCCI

BSEE, City College of New York, 1952; MSEE Program, Polytechnic Institute of Brooklyn, 1957. Systems Project Engineer, ITT Laboratories.



LAMAR DUKES

BSEE, University of Pittsburgh, 1946. Section Head, Modulator Division, FXR, Inc.; Project Engineer; Airborne Instruments Laboratory; Systems Engineer, Sperry Gyroscope Corp.



ARNOLD G. KRAMER

BS Physics, MIT, 1952; MS Physics, MIT, 1954. MTS, Research Laboratories, Hughes Aircraft Company; Development Engineer, Microwave Associates.



EDWARD F. DOWDELL

BEE Program, Polytechnic Institute of Brooklyn. Microwave power supplies design, FXR, Inc.; Impulse generator design, Empire Devices Corp.



ALBERT D. ARFIN

BS Physics, Hofstra College, 1959. Project Engineer, Airborne Instruments Laboratory; Design Engineer, Anton Electronic Laboratories.



LEO BRECHT

BS Program, Hofstra College; Millimeter Components Design, FXR, Inc.; High Power Microwave Components, Sperry Gyroscope.



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COMPONENT	MODEL NO.	RANGE	ACCURACY	FEATURES
High Precision Variable Attenuator	P150	0-60 db. cal. Max. atten. > 80 db	$\pm 1\%$ of full scale to 60 db	Insertion loss 1 db max. VSWR 1.15 max. Extremely high accuracy, direct reading.
Direct Reading Frequency Meter	P220	10-15 kmc/s	0.1% of dial reading	25% nominal power dip at resonance. Non-contacting, double choke plunger. Readability engineered dial.
Universal Slotted Line Probe Carriage	XV290	Accommodates 8.2-40 kmc/s slotted sections	Probe travel vernier resolution greater than 0.1 mm	Universal carriage, multiple speed drive, cast aluminum housing.
Slotted Section	P285	2 wavelengths at 10 kmc/s min. carriage travel	Residual VSWR < 1.01 irregularity < 0.005	Cast aluminum, precision machined to waveguide dimensions.
Multihole Coupler	P175	Coupling—3, 6, 10, 20 db nom. Directivity—40 db min.	Average coupling within 0.4 db of nom. $\leq \pm 0.5$ db coupling variation.	Main line VSWR 1.05 at 6-20 db, 1.1 at 3 db. Secondary line VSWR < 1.2 Broadband, coupling variation minimized.
Crossguide Coupler	P170D	Coupling—20 db nom. Directivity—20 db min.	Within 1.7 db of nom. coupling	VSWR < 1.1 4 port
Direct Reading Calibrated Variable Attenuator	P145	0-20 db	± 1 db from 0-10 db ± 2 db from 10-20 db	Insertion loss 0.5 db max. VSWR 1.15 max. Readability engineered dial.
Fixed Attenuator	P155	3, 6, 10, 20, 30 db nom.	0.1 db per db, ± 1 db min.	VSWR < 1.15 Supplied in any value to 30 db.
Crystal Detector Mount	P200	—	—	1N23B crystal, non-contacting, micrometer driven short, locking provision.

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Model 500 MICROWAVE POWER SUPPLY

Some of the features incorporated into this medium priced Microwave Power Supply, which advances the state-of-the-art, are:

1. A dc oscilloscope, with sweep functions derived from the internal modulator, is made a part of the power supply. Since the waveforms are locked, sync is automatic. Thus a detected klystron mode may be observed when tuning the tube or making frequency measurements, or a number of cycles of square-wave modulated signals may be presented by simply actuating the function switch.
2. Several plug-in modulators are made available including a precision 1000 cps square-wave modulator with internal synchronization voltage derived from a tuning fork. A portion of the tuning fork signal is conveniently available for use with coherent detectors in other parts of the system. A general purpose modulator is also available. Maximum flexibility is achieved by use of these plug-in modulators.
3. Special care and attention to extended applications is given to the repeller circuits. Provision is made to operate two klystrons requiring similar heater and beam voltages simultaneously by supplying independently variable repeller voltages. AFC correction voltages can be injected into one of the two repeller channels so that either the difference frequency between the two klystrons may be maintained constant for heterodyne receiver applications, or a single klystron can be frequency stabilized against an external reference. A fixed 1000 vdc repeller supply at 10 ma maximum is separately available for use with signal sources in systems where the klystron repeller voltage is tracked with the mechanical cavity adjustment.
4. A new technique for introducing the square-wave modulation into the repeller circuit results in exceptionally low frequency modulation during the klystron oscillation period, in contrast to the usual circuitry where tilt or droop of the square-wave flat top results in unwanted frequency modulation. The square-wave modulation may be applied either to the klystron repeller circuit or to the grid circuit of backward-wave oscillators and gridded klystrons.

Introducing a new concept in power supplies for microwave tubes. For the first time, a power supply truly conceived for making microwave measurements of the most exacting nature is offered. All potentials, including the DC heater supply, are exceptionally well regulated. Increased versatility is achieved by features such as exceptionally well regulated plug-in modulators and a built-in CRO for visual observation of the detected signal. This permits complete integration of the power supply into the microwave system.

5. A continuously variable and regulated dc heater supply is incorporated to reduce the usual spurious frequency modulation of microwave oscillators resulting from the use of ac on the heater. Since this supply is continuously variable over a wide range, it is possible to operate voltage tunable magnetrons and microwave triodes as well as standard tubes. Because of this versatility, obsolescence is forestalled as the microwave tube art advances.
6. The beam, repeller and heater supplies are isolated and have separate terminal pairs permitting polarity reversal and interchange of grounding point.
7. A group of accessories extend the application to more specialized problems:
 - a) A fixed 2 kv, 200 ma beam supply, as a separate unit, extends the beam voltage range from 2.2 to 4.2 kv. The basic power supply transformer is insulated to accommodate this voltage extension.
 - b) A special dc transformation unit permits AFC correction voltages at ground level to be coupled into the repeller circuit operating at a large potential with respect to ground.

SPECIFICATIONS

	VOLTAGE	REGULATION From 105-125 vac	INTERNAL IMPEDANCE	RMS RIPPLE	DIAL ACCURACY
Beam	Continuously variable 0-2.2 kv at 0-200 ma max. (2.2-4.2 kv optional)	$\pm 0.005\%$	< 0.2 ohms	1 mv	0.05% resolution 0.5% resettability
Grid	-250 to +100 vdc continuously variable 0-20 ma	$\pm 0.005\%$	< 0.5 ohms	1 mv	0.05% resolution 1% resettability
Filament	0-12.6 vdc continuously variable 0-5 amp dc	1%	—	1%	—
Repeller	1) 1000 v fixed 2) 20-1000 vdc continuously variable 3) 20-1000 vdc continuously variable	$\pm 0.005\%$	< 100 k ohm	0.5 mv	0.05% resolution 0.5% resettability

Modulation • Plug-in capability including square-wave at 1000.0 cps and 1000 cps $\pm 10\%$, sawtooth at 40-400 cps, and variable frequency square-wave 200-4000 cps.
• Synchronization and external CRO drive outputs available.

Model 515 POWER SUPPLY

A low priced, companion klystron power supply is available to accommodate most medium voltage tubes:

- Repeller 20-1000 vdc, < 0.5 mv rms ripple
- Beam 200-800 vdc, 0-100 ma, < 3 mv rms ripple
- Heater 6.3-12.6 vdc, 0-2 amp
- Internal modulation
- Overload protection

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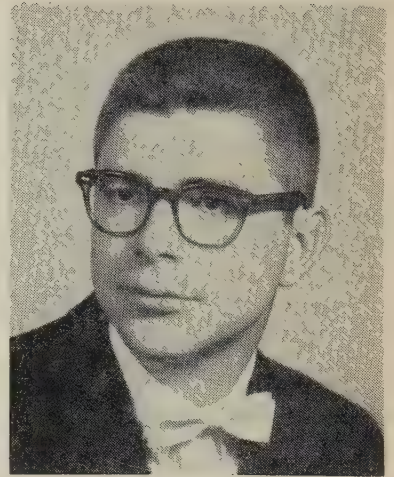


CONTRIBUTORS IN THIS ISSUE

ROBERT L. FORWARD received his BS in physics from the University of Maryland in 1954, served two years as a Lieutenant in the USAF, and then attended UCLA under the Hughes Work-Fellowship Program, graduating in 1958 with an MS in physics. He is presently at the University of Maryland on a Hughes Staff Doctoral Fellowship working on a thesis in experimental general relativity.

Mr. Forward has been associated with the Hughes Research Laboratories, Division of Hughes Aircraft Company, in Malibu, California. His work there has been primarily in the application of solid-state masers.

He is a member of the PGMTT, American Physical Society and Sigma Pi Sigma.



FRANCES RICHEY received her BA degree, with honors in physics, from Wellesley College in 1951. She did graduate work at MIT (1952) and UCLA (1952-56) receiving an MA in physics in 1954. From 1952-1955 she was a staff member of the Visibility Laboratory, Scripps Institution of Oceanography, University of California. Since 1955 she has been a teaching assistant in physics at UCLA, a staff member at Hughes Research Laboratories, and presently an associate at E. H. Plesset Associates, Inc.

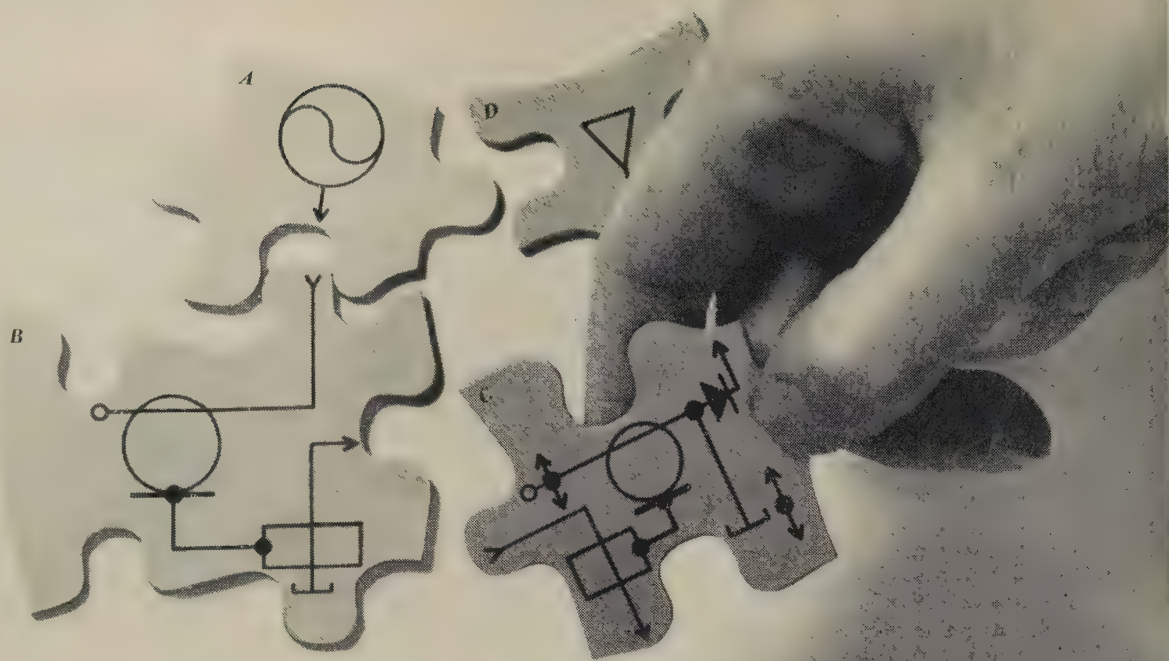
Miss Richey's fields of specialization include under-sea and atmosphere visibility, multiple scattering, spectroscopy of rare earth crystals, radar systems analysis, antenna resolution studies, and inertial guidance.

She is a member of the American Physical Society, Optical Society of America and the Society of Sigma Xi.

HAROLD SHNITKIN was born in October, 1924, and graduated from Brooklyn Technical High School in 1943. After serving with the U.S. Army as a radio repairman, he received his BSEE from Union College in 1950 and his MEE from Yale in 1951. He worked at Airborne Instruments Laboratory on special microwave tube applications until 1952, and at Fairchild Guided Missile Division on antenna and microwave circuits until 1954.

He is now Manager of the Advanced Microwave Development Department at W. L. Maxson Corp., responsible for the development of solid state microwave devices and electronically steered antennas. He also holds the post of Adjunct Associate Professor of Physics at Hofstra College, where he gives graduate instruction in the field of microwaves. In addition he served as panel member during the Electronically Steered Antenna Symposium at the 1960 IRE Convention.





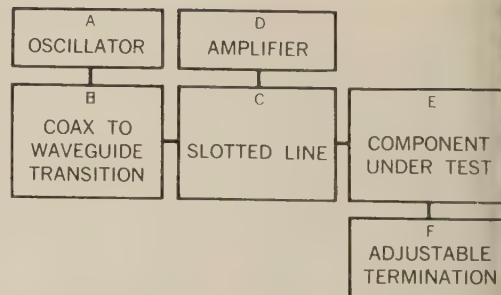
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FIRST OF TWO PARTS

INTRODUCTION

In recent years there has been an increasing demand for high-gain and narrow-beam antennas in the communications as well as the radar field. To meet this demand, engineers have gone to larger and larger antennas as well as to pushing frequencies upwards to where power generation and atmospheric attenuation present serious limitations. The high-gain requirement stems primarily from the desire to communicate over greater distances while the narrow-beam requirement has been dictated by the increasing precision of direction-finding systems. The chief difficulty in satisfying the large antenna requirement encountered during repositioning of the antenna beam directions, a basic requirement of any scanning system. Additional complications arise since the beam position of a narrow beam antenna must be readjusted more frequently than that of a broad-beam antenna if it is to cover the same solid space angle in the same amount of time. Thus, a practical limitation has been encountered in terms of the mechanical inertia of the antenna and the angular accelerations due to beam repositioning, demanding unrealizable driving torques accompanied by excessive mechanical stresses. Thus, a preferable system should be considered which utilizes a stationary antenna, excited by means of phase shifting components, whose phase adjustment can be made to prescribe the direction of the antenna beam.

The purpose of this paper is to present the phase excitation requirement for an electronically scanning aperture, several schemes and configurations which would meet this requirement, and the phase shifting techniques and components whose characteristics would satisfy the needs of a practical antenna. The subject matter treated here is by no means restricted to the microwave frequencies but is directly applicable to rapid scanning and high resolution direction finding at any lower radio frequencies.

I. MECHANICAL VS. ELECTRONIC SCANNING

Rapid antenna scanning with mechanical techniques presents several limitations. Exceptionally high torque drives are required to accelerate a physically large antenna possessing a large moment of inertia. These accelerations give rise to high structural stresses in addition to those produced by centripetal action, which will result, if not in failure, in antenna distortion and deterioration

of radiation pattern. Electronically scanning antennas also suffer from an inertia phenomenon and thus limit the acceleration of beam motion. In this case, however, the high inertia of a massive antenna structure is replaced by that of small mechanical components or the electrical inertia (inductance) of an all-electronic phase shifter. The attractive features of electronic scanning are that the inductive inertia can be overcome by voltages rather than mechanical torques and that a wide range of beam positioning programs are permissible because of the lifted acceleration limitation. Electronic scanning permits a portion of the scanning volume to be favored or prescribed scan angle regions to be skipped.

The most effective use of electronically scanned antennas can be made where rapid scanning must be combined with the high gain and narrow beams of large antennas and where special beam position programming is desirable.

III. ANTENNA PHASING REQUIREMENTS

A. Phase Taper Requirement

An antenna array will generate a collimated beam, i.e., produce a radiation maximum in one direction, if each element of the antenna is electrically equidistant from the point of reception. Thus if the separation between transmitting and receiving antenna is much greater than the dimensions of the antenna itself, and if the antenna consists of a plane surface, the phasing requirements can be restated as follows:

The rate of phase advance (known as "phase taper") along any line across a plane aperture must be uniform.

Whenever possible a plane antenna surface and uniform element spacing is usually chosen to simplify the phase programming, to permit identical radiation patterns for the elements comprising the array, and to achieve predictable radiation characteristics.

A mathematical relationship between the direction of beam pointing and the phase tapers existing along orthogonal axes in the plane of the antenna array is needed. If X and Y axes are chosen, as shown in Figure 1, and the direction of beam pointing is measured as the angle formed between the beam direction and the two coordinate axes; (θ_x and θ_y , respectively) then in terms of β_x and β_y , the phase tapers along the X and Y axes (in radians per unit length): $\cos \theta_x = \frac{\lambda \beta_x}{2\pi}$ and $\cos \theta_y = \frac{\lambda \beta_y}{2\pi}$.

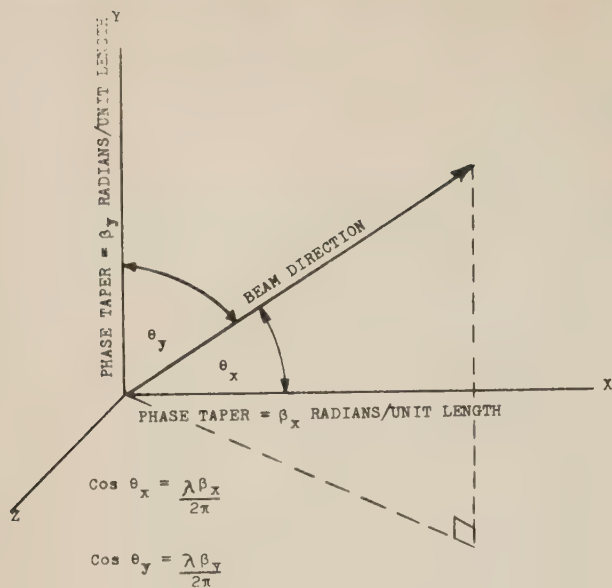


Figure 1 — Coordinate system.

where λ is the wavelength in the same units as β . The above expression permits determination of the phase values of each element in the array in respect to a reference point, once the element spacing is known.

Quantitatively speaking, the end elements of an antenna array will vary between 180 and 250 degrees for each beamwidth of scan in respect to the center element. Thus, if twenty beamwidths are to be scanned about the antenna normal, the end elements may have to undergo maximum phase changes from +2500 to -2500 degrees. Since, however, a phase shift of ϕ degrees is indistinguishable from a phase shift of $\phi \pm 360N$ degrees, where N is any integer, phase shifters with a 360 degree phase excursion will suffice.

In the event of cylindrical or conical arrays the phase-taper concept is meaningless and a more complicated trigonometric relationship for phase collimation must be derived, as shown in Figure 2 and the following equation:

$$\Delta\psi = \frac{2\pi R}{\lambda} \cos \theta [1 - \cos \alpha]$$

- where $\Delta\psi$ is the relative phase of excitation
- R radius of cylindrical array
- θ beam pointing angle in plane orthogonal to that of element phase centers
- α angular position of cylindrical array element

Additional treatment of conical geometrics can be found in reference 1.

B. Scan Volume

The maximum scan volume of an electronically scanned antenna is determined by the radiation pattern of the individual element (known as element factor), by the separation between elements to avoid multiple beams (known as grating lobes), and by excessive mutual coupling.

It is essential that the directivity of the element is never zero within the scanning volume. This requirement, for example, does not permit end-fire radiation of a dipole over a ground plane.

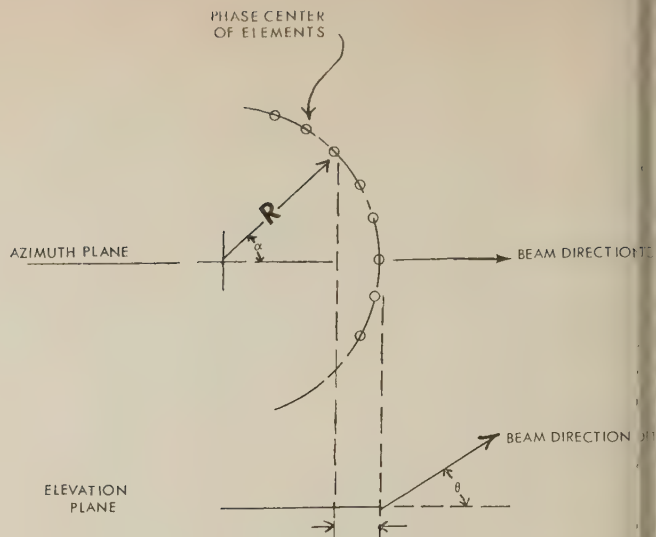


Figure 2 — Phase collimation for cylindrical geometries.

Since the element factor remains fixed while the array factor is being scanned, one cannot rely upon reduction of grating lobes by means of element factor for all angles of scan.

Thus a limitation must be placed upon the maximum element spacing, as expressed by the following equation:

$$d_{\max} = \frac{1 - \frac{1}{N}}{1 + \sin \theta} \lambda$$

where d and λ are the element separation and wavelength respectively, in the same units; N , the effective number of rows (or columns) of elements, evaluated as the equivalent number of rows of elements for uniform excitation and equal beamwidth; and θ , the maximum off-broadside scan angle.

This equation assures that the null of the closest undesirable grating lobe falls along the axis of the array and that its magnitude is zero anywhere in front of the plane of the array. For example, the maximum separation for a large non-scanning broadside antenna is roughly λ and for

a ± 90 degree scan is $\frac{\lambda}{2}$. In case of non-uniform ele

ment spacing (or element polarization) additional grating lobes may occur. These exist not in a direction corresponding to the actual or average element spacing but in a direction corresponding to the spacing between identically polarized or off-set radiating elements (usually twice the actual spacing). As derived in reference 2 the magnitude of these grating lobes increases with increasing off-center spacing of radiating elements as well as with increase in element polarization inclination. In contrast to the grating lobes produced by uniformly spaced as well as polarized radiating elements, these grating lobes are much smaller in magnitude and point approximately midway between the main beam and the grating lobe for uniform elements.

Coupling effects between one radiating element and another one, which may be located in the same linear array or in an adjacent one, are most objectionable near end-fire radiation. This is primarily due to the in-phase voltage vector addition at end-fire since the phase velocity within the array is almost equal to the external velocity of propagation. It manifests itself by undesirable im

edance conditions and phase errors which vary so rapidly with scan angle to prevent their correction. The results are higher radiation side lobes, beam widening, and loss of gain near end-fire.

2. Aperture Design Problems

Many of the design problems met in ordinary two dimensional antenna arrays exist in increased complexity for the electronically scanned array. This is primarily the result of varying rather than fixed element phasing, required for scanning. Quantities such as antenna element impedance, antenna match and antenna gain are no longer constant but vary with antenna beam pointing.

Many analyses of element impedance in the presence of other radiating elements have been made under the heading of mutual coupling effects (See references 3, 4, 5 and 6). It is, however, wise to rely heavily upon experimental work involving the element configuration and spacing demanded by a particular design. Thus the actual load impedance as seen by a phase shifter or a corporate feed can be established and an impedance transformation which yields a good match accompanied by minimum amplitude and phase errors can be designed. Mutual coupling effects in adjacent linear array systems, however, give rise not only to element impedance variations but also to absorption and reradiation of energy from one array to the next. Because phase tapers of adjacent arrays in a planar aperture are equal, phase addition of the mutual coupled energy will occur. A change in both phase and amplitude of the total radiation, which reaches a maximum near the termination end of the array, will be produced. In many cases phase and amplitude of the element excitation can be adjusted in the design of the linear array to counteract this effect. However, if this effect is sufficiently destructive, coupling between arrays must be reduced by either adding directivity to each radiating element or by means of a ground plane choke design which prevents currents from adjacent elements to couple to each other (see reference 4). It can further be shown that if an array of linear arrays is to radiate normally, mutual coupling gives rise to a reflected wave as well as a forward traveling one. Its magnitude can be equivalent to a 2.0 standing wave ratio, i.e., a loss of 0.5 db in gain when the aperture radiates normally.

The matching requirement for electronically scanned antennas is usually considerably stricter than that for fixed beam antennas. Reflections from radiating elements will travel back to the corporate feed which, unless it consists of hybrids or directional couplers, will reflect these with almost 100 percent efficiency. By the time these reflections are reradiated from the aperture they will have passed through the phase shifting network three times and thus will collimate in a beam equivalent to three times the phase taper to which the phase shifters have been set. This is true only for reciprocal phase shifters; otherwise break-up into many smaller side lobes will occur. Furthermore, linear arrays are subject to extremely large reflections when scanning through the broadside angle since at broadside all radiating elements appear to be in parallel (or in series) with the input generator. This can, of course, be avoided by including a matching transformer with

each radiating element to match out the individual radiation resistances.

The gain of an electronically scanned antenna is a function of the element spacing, the number of elements, as well as the direction of beam pointing. Antenna gain will increase with element spacing as long as no grating lobes are produced. Studies made by R. W. Bickmore (reference 7) have shown that if the stated element spacing for grating lobe reduction is not exceeded, the effective aperture at broadside radiation is equal to the projection of the actual aperture upon a plane normal to the direction of radiation. In this case the element gain has been accounted for by extending the effective aperture area beyond the center lines of the outermost elements by a radius corresponding to the effective aperture area of the individual element. Reference 7 further shows that the projected area computation breaks down approximately at scan angles of 80 degrees. From here on gain again increases with scan angle until the value normally associated with end-fire gain is achieved.

IV. TYPES OF ANTENNA SYSTEMS

There are three general types of antenna systems, which can be employed to scan an antenna beam without repositioning the antenna aperture. These are:

1. The frequency-scanned system
2. The phase shifter system
3. The beam-switching system

These systems differ from each other in their physical construction, their speed of switching, their accuracy, and in their dependence upon special components.

The frequency-scanned antenna is the simplest and most compact one requiring, however, a more complex receiver and transmitter, which perform equally well over a broad band of frequencies and which have provisions for accurate frequency control and read-out. Frequency-scanned antennas are usually limited to scanning in one plane, but can be designed to operate either about the aperture normal (broadside) or close to the aperture plane (end-fire). The antenna itself has no moving parts and no electronically activated circuit components. Beam positioning is extremely fast as well as very accurate.

The phase shifter antenna is quite complex since it requires at least one phase shifter per radiating element. These phase shifters must be driven, either mechanically or electrically, from a central control point (usually a computer) to establish the required phase front for a collimated beam. This computer also serves as a beam position read-out device, as needed in direction finding. The speed of beam positioning is definitely slower for phase shifting than for frequency scanning; the mechanical phase shifters permit at best five millisecond per beamwidth scan rates, while at present 0.1 millisecond per beamwidth can be achieved with electronic phase shifters. Phase tolerances of mechanical phase shifters may only be a few degrees while that of electronic phase shifters may go as high as ± 30 degrees; for this reason an all electronic antenna systems can be expected to possess higher side lobes, loss in gain, and less beam positioning accuracy.

The beam switching antenna is usually physically the largest one since it is basically made up of a number of

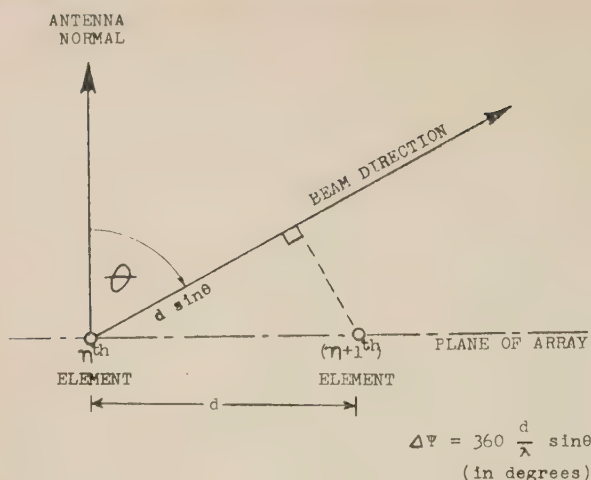


Figure 3 — Phase taper-scan angle relationship.

antennas pointing in different directions but utilizing the same aperture. In principle, a number of feeds, each corresponding to one beam direction, are connected to the same aperture in a manner that establishes the required aperture phase tapers. In addition, a multi-port switch is essential for beam position selection, unless a separate transmitter and/or receiver can be provided for each of the beam positions. The speed of scanning, i.e., switching, depends upon the particular type of switch employed (mechanical or electrical) and is the same as that of the phase shifters employed in the phase shifter antenna. Furthermore, aperture phase accuracy is extremely good since it does not depend upon the characteristics of the switch. Consequently, low side lobes and high positioning accuracy can be expected. It should be kept in mind that this type of antenna will not scan uniformly, but step-scan between predetermined positions, as selected in the design.

V. THE FREQUENCY SCANNED ANTENNA

The frequency-scanned antenna generates an aperture phase taper which can be adjusted by means of frequency. This is accomplished by feeding each radiating element through unequal lengths of transmission line. An ideal antenna array of uniformly spaced radiators, separated by a distance d , must be excited so that any two adjacent elements are fed through feed lines of equal phase constants but differing by the same length L . This creates a phase difference of $\Delta\psi$ between them, so that

$$\Delta\psi = \frac{360L}{\lambda_g} \text{ degrees}$$

where λ_g is the wavelength in the feed line. Since a phase shift of $\Delta\psi + 360N$ is independent of the integer N , the phase difference between elements can be expressed more generally as:

$$\Delta\psi = \frac{360L}{\lambda_g} + 360N$$

In accordance with Figure 3, the resulting collimated beam will radiate in the direction θ , given by the expression:

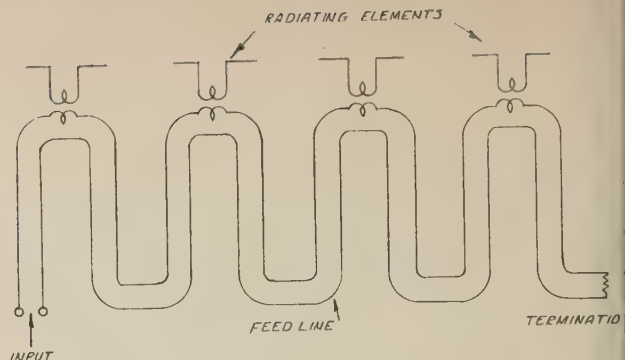


Figure 4 — Series fed frequency scanned array (schematic).

$$\sin\theta = \frac{\lambda L}{\lambda_g d} + N \frac{\lambda}{d}$$

where λ is the free space wavelength.

This equation indicates that a high $\frac{L}{\lambda_g}$ ratio demands large negative values of N ; furthermore, the derivative

$$\left| \frac{d\theta}{d\lambda} \right| = \sec\theta \frac{L\lambda_g}{d\lambda^2} + \frac{N}{d}$$

increases for large L values for a given scan angle, element separation, wavelength and cut-off wavelength. Thus the differential feed delay line, L , determines the frequency scanning rate (degree per megacycle).

There are two methods of designing a frequency scanned array: series and parallel. The series method is a traveling wave array, i.e., an iterative structure consisting of equal delay sections and a loosely coupled radiating element (see Figure 4). In this configuration the delay becomes cumulative. The parallel method makes use of a corporate feed or power divider structure from which all radiators are fed through different lengths of transmission line (see Figure 5). For reasons of compactness series feeds are more practical for frequency scanned arrays, while parallel feeds find more application in phase shifter antennas.

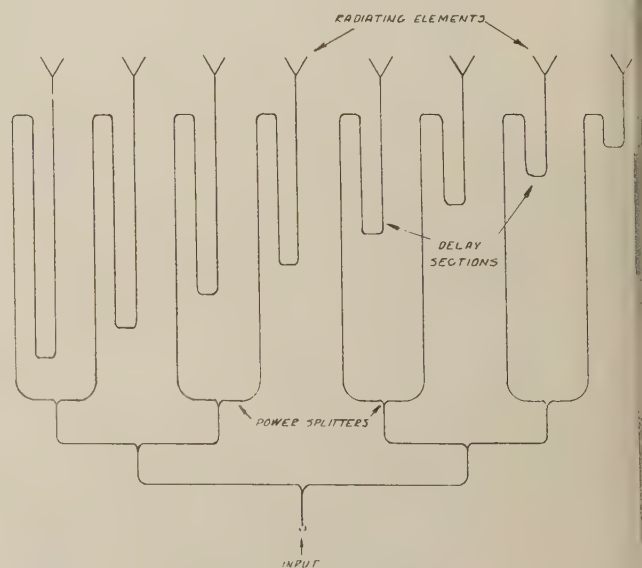


Figure 5 — Parallel fed frequency scanned array (schematic).

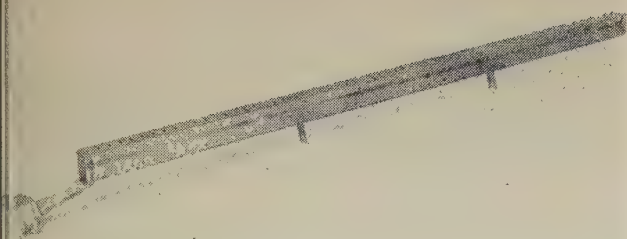


Figure 6 — Practical frequency scanned arrays with shunt radiating slots.

Two practical methods of constructing a frequency scanned array are illustrated in Figures 6 and 7. Both make use of a waveguide serpentine structure (also called "snake-feed") to provide the phase delay, and loosely coupled slot radiators. The Figure 6 design provides transverse polarization and employs resonant longitudinal shunt slots whose off-center displacement control the magnitude of the radiated voltage.

The Figure 7 design provides axial polarization and employs non-resonant, series slots whose length controls the magnitude of the radiated voltage. The two illustrated designs provide sixty degrees of scan with better than -20 db side lobes. In addition, it should be mentioned here that extensive matching structures are required to avoid both serious phase distortion and high standing wave ratios.

VI. THE PHASE SHIFTER ANTENNA

This type of antenna requires either a series or a parallel corporate feed to divide the power into the correct amounts as dictated by the number of elements and the aperture illumination (see Figures 8 and 9). This is accomplished by directional couplers or hybrids, if good match and good phase accuracy are needed to provide high beam-positioning accuracy and low side lobes (see Figure 10).

A parallel corporate feed might consist of multiple branching circuits consisting of Y-type or hybrid power splitters as in Figure 5 or a pill box feed, as in Figure 11. The latter consists of a sectoral waveguide horn

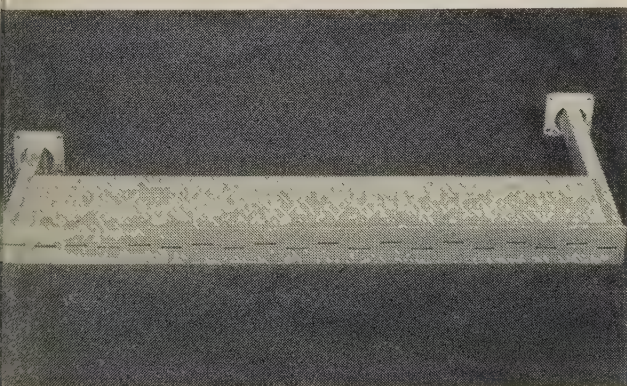


Figure 7 — Practical frequency scanned arrays with series radiating slots.

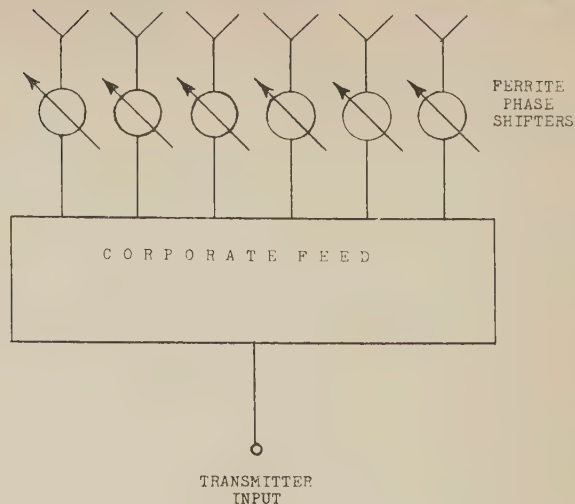


Figure 8 — Schematic of phase shifter scanned antenna.

terminated in a cylindrical parabolic reflector which is so designed that the wave travels around a partition similar to a 180° E-plane bend. The parabolic reflecting surface produces a linear phase front at the output port which is then subdivided by means of bifurcations normal to the E plane into as many output terminals as there are radiating elements. Unequal spacing of these bifurcations can be employed to obtain a variety of amplitude distributions. A two dimensional extension of the pill box feed is a combination of a primary feed horn with a paraboloid reflector (or a lens) containing a phase shifting device.

In the case of main line feeding (or series feeding) the corporate feed and the phase shifters cannot be physically separated. The circuit arrangement is similar to that shown for frequency scanning (Figure 4) except that the delay of the feed line must be replaced by that of phase shifters. This technique has two main disadvantages. The insertion losses of all phase shifters are cumulative and will, in many cases, exceed practical limitations; furthermore, this arrangement is not suit-

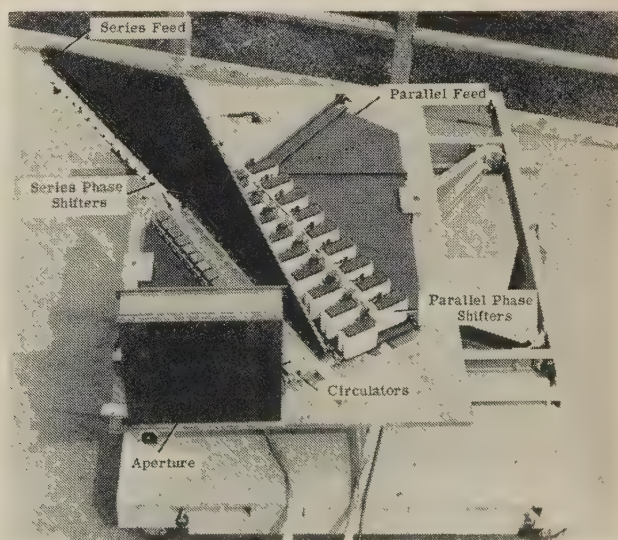


Figure 9 — Corporate feed and ferrite phase shifters of an antenna system.

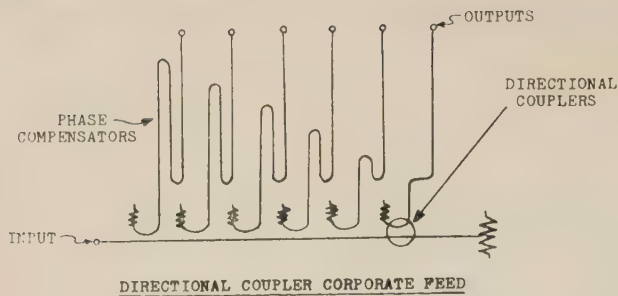


Figure 10 — Directional coupler feed.

able for high power application (transmitters) since the phase shifter nearest the input must be able to handle the total transmitted power. In the case of parallel feeding, the power is first divided and the power rating of each phase shifter thus reduced. Finally, a form of phase compensation (usually line lengths) must be provided to avoid frequency scanning in series fed systems. Specifically, the path lengths from the antenna input terminal to each of the radiating elements must be equalized. Series feeding, however, offers the advantage of assuring an almost linear phase taper across the feed, thus greatly reducing sidelobes arising from both square-law and cubic phase errors (reference 8). This occurs since all phase shifters are set to equal phase values, and systematic phase errors can only change the array phase taper in a uniform manner; square-law and cubic phase errors are therefore limited to random phase shifter deviations.

Peculiar to most phase shifter antennas is the need for a computer to convert beam pointing angle information into the correct value of phase shifter excitation. This computer must incorporate the phase taper calculation determining the phase settings of each phase shifter as well as the phase vs. excitation characteristic of the phase shifter itself. Such a computer could be simplified considerably if a linear phase shifter characteristic, independent of frequency, power, and temperature could be provided. Besides yielding accurate results, the computer must be sufficiently fast so that the total time needed for computing all phase shifter excitations is less than 10 per cent of the required beam positioning time interval (slew time).

An example of a rather simple computer can be found in reference 9. Here the required phase values for each of a large number of discrete beam positions have been computed in advance. Precision resistors are provided for each phase shifter and each beam position, to produce the correct current for setting each ferrite phase shifter to the computed phase value. A multi-position, multi-gang switch selects the appropriate resistors for each beam position.

The performance of the phase shifter antenna depends mainly upon the quality of the individual phase shifters employed. For this reason, a listing of the desirable phase shifter characteristics has been prepared, which will be employed for evaluation of different designs.

1. Minimum phase variation must be 360 degrees.
2. Phase setting must be nearly independent of fre-

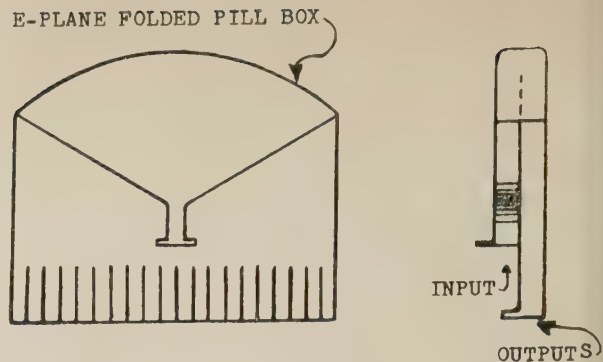


Figure 11 — Folded pill box feed.

quency, temperature, and power level. Phase shift common to all phase shifters of one antenna due to the above causes is permissible since it will not affect beam pointing, but simply advance or retard the effective antenna phase center.

3. Insertion loss must be reasonably low.
4. Power handling capability must permit radiation of total transmitter power without breakdown or phase distortion.
5. Mechanical or electrical inertia should be low to permit phase shifting within the required beam shift interval with the available driving power.

There are five major phase shifting techniques which can meet these requirements:

- A. The mechanical phase shifter
- B. The ferrite phase shifter
- C. The semi-conductor phase shifter
- D. The frequency conversion phasing scheme
- E. The ferrite controlled radiating slot

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Effects of EXTERNAL NOISE On RADAR PERFORMANCE

ROBERT L. FORWARD *
FRANCES RICHEY * *

HUGHES AIRCRAFT COMPANY
RESEARCH LABORATORIES
Malibu • California

Introduction

Extensive development of low-noise receivers and receiver components, such as backward-wave amplifiers, masers, and parametric amplifiers, has made it important to ascertain the degree of improvement to be expected in the performance of present-day systems from the use of very low-noise r-f amplifiers. A review of the manner in which external noise sources and receiver noise affect the minimum detectability of a signal and estimates of the magnitudes of such external noise sources will be given in the following discussion.

This paper is intended to aid those concerned with the application of low-noise microwave receivers to future systems. The frequency range covered is 1 to 100 kMc. In using this paper, the reader must have in mind some particular system application, which will determine the frequency, mode of operation (radar or one-way communication), area of application (low or high altitude, horizontal or vertical scan), type of antenna, etc. The approximate antenna temperature may then be determined by consulting Figures 1 through 4,** as discussed in the following sections. Any external sources other than those accounted for in the antenna-temperature calculation, such as interference, must then be added to give the total external noise entering the antenna along with the signal. By using Figures 5 through 8, which are discussed in detail below, one can then compare the ranges that would be obtained with different receivers in the system.

The reader must be cautioned that, due to the lack of suitable very low-noise receivers in this frequency range, there have been very few experimental measurements of external noise sources. All of the graphs are merely estimates by the authors and are based on whatever information is available.

Calculation of Minimum Detectable Signal

In order to discuss the manner in which external noise sources and receiver noise affect the detectability of the signal, it is necessary to examine the relationship between

the probability of detection of a given signal, the signal-to-noise ratio before amplification, the false-alarm rate, and the number of pulses integrated. Only the signal-to-noise ratio is of concern in the following discussion. If in a particular problem a certain false-alarm rate is allowed and a certain fixed number of pulses over which an integration can be performed is chosen, then a definite minimum signal-to-noise ratio X is required in order to ensure any required probability of detection.¹ If the signal-to-noise ratio available at the receiver before amplification is greater than or equal to X , the minimum required, then the probability of detection of the signal will equal or exceed the required probability of detection.

$$\frac{\text{signal power}}{\text{noise power}} = \frac{S}{N} \geq X, \quad (1)$$

where X is a fixed number which depends on the choice of values for the required probability of detection, false-alarm rate, and number of pulses integrated.

The noise power can be found by summing all external noise powers and adding the total to the receiver noise power. However, it is more convenient and more physically meaningful to discuss an effective noise temperature T_e defined by the relation

$$N = kT_e B, \quad (2)$$

where k is Boltzmann's constant, and B is the bandwidth.

*** Comment has been made that the sun temperature and the galactic noise temperature does not agree with Reference 10. For the sun temperature, the data quoted in Reference 10, Figure 2 is probably based on a very quiet sun condition as it seems to be an order of magnitude lower than other references. (See also the American Institute of Physics Handbook, page 6-121, Figure 60-1. At 1 KMc the temperature of the sun is more like 10^6 °K rather than 10^5 °K as in Reference 10). As stated in the report, the noise from the sun varies over two orders of magnitude so that any curve is only an order of magnitude estimate. For the galactic noise temperature, Reference 10 assumes a wavelength dependence of 2 whereas astronomers have always been of the opinion that the galactic noise varies as 2.5. In fact the approximation curve in Reference 10, Figure 3 has a substantially different slope than the two calculated curves. Considering the spread in the galactic noise from the center to the pole (1 to 40°K at 1 KMc) the difference between the "average" galactic noise in this paper and Reference 10 is not important.

* Present address: Department of Physics, University of Maryland, College Park, Maryland.

* Present address: E. H. Plesset Associates, Inc., Los Angeles, California.

TABLE I
Sample Calculations for the Estimate of Antenna Temperature
for a Ground-based Satellite-tracking Station (5 kMc)

Portion of the Beam	$\bar{G}_1 \frac{\Delta \theta_1}{2\pi}$	Galactic and Atmospheric Emission (°K)	Reflector Absorption (°K)	$\bar{G}_1 \bar{T}_1 \frac{\Delta \theta_1}{2\pi}$ (°K)
Main beam*				
$0 < \theta \leq 0.2^\circ$	0.840	4		3.3
Upper side lobes				
$0.2^\circ < \theta \leq 30^\circ$	0.075	5		0.4
Upper horizontal lobes				
$30^\circ < \theta \leq 90^\circ$	0.022	50		1.1
Lower horizontal lobes				
$90^\circ < \theta \leq 120^\circ$	0.022	90 % x 50	10 % x 300	1.7
Lower and back lobes				
$120^\circ < \theta \leq 180^\circ$	0.030	90 % x 5	10 % x 300	1.0
Disk absorption			1 % x 300	3.0
$\sum_1 \left(\frac{\Delta \theta_1}{2\pi} \right) \bar{G}_1 \bar{T}_1 = 10.5^\circ \text{K}$				

If T_A is the equivalent antenna temperature, as defined in the next section, and T_R is the equivalent noise temperature of the receiver, then the condition which establishes the value of the minimum signal-to-noise ratio follows immediately from (1) and (2):

$$\frac{S}{kB(T_A + T_R)} \geq X. \quad (3)$$

If the above condition is not satisfied, the signal will be indistinguishable from the noise.

Equation (3) is more useful, however, in a transposed form:

$$T_A + T_R \leq S/kBX. \quad (4)$$

From this relationship one can immediately understand that it will be useful to reduce the receiver noise temperature T_R only if the sum $(T_A + T_R)$ is greater than S/kBX . To state the situation in a mathematical way: if the ratio of the signal power to the external noise power coming into the antenna is greater than the minimum value X ,

$$S/kBT_A > X, \quad S/kBX > T_A, \quad (5)$$

and if the signal-to-noise ratio is degraded, by the addition of the receiver noise to the external noise, to a value below the minimum value X ,

$$S/kB(T_A + T_R) \geq X, \quad T_A + T_R \geq S/kBX, \quad (6)$$

then under these conditions, reducing the receiver noise temperature allows one to detect a signal which would otherwise be below the threshold detectability.

Equivalent Antenna Temperature

At microwave frequencies, antenna noise is caused almost exclusively by thermal energy originating from an

exchange of radiation with the medium in which the antenna is imbedded. Since the thermal radiation received by the antenna depends on its orientation, antenna noise can be described only by an average value, not by a uniquely determined quantity.

Insofar as the antenna is considered to be a generator of noise power for the rest of the system, it can be considered simply as a resistor, the value of which is the radiation resistance of the antenna at temperature T_A . This temperature is defined as that which a resistor must have to produce noise power equal in amount to the antenna noise power.

If the antenna is in thermal equilibrium with its surroundings, its equivalent temperature can be expressed as

$$T_A = \frac{1}{4\pi} \int G(\theta, \phi) T(\theta, \phi) d\Omega, \quad (7)$$

where $G(\theta, \phi)$ is the directional antenna gain function and $T(\theta, \phi)$ is the directional effective temperature. Equation (7) states that the equivalent antenna temperature is equal to the average temperature of the medium in which the antenna is imbedded, weighted by the directional gain function. In order to evaluate T_A , it is necessary to estimate the values of $T(\theta, \phi)$ that can be expected from different parts of the antenna environment.

For practical applications it is usual to replace the three-dimensional integral of (7) with a two-dimensional sum of the following form:

$$T_A = \sum_i \bar{T}_i \left[\bar{G}_i \frac{\Delta \theta_i}{2\pi} \right], \quad (8)$$

where $\bar{G}_i \frac{\Delta \theta_i}{2\pi}$ and $\bar{T}_i$ are average gain figures and temperatures, respectively, in the direction intervals $\Delta \theta_i$. Examples of such calculations for sample applications are given in Tables I and III, which follow a detailed discussion of the sources of the temperatures $\bar{T}_i$.

* The angular width of the main beam is 0.2 degree. The half-power beam width is 0.05 degree.

TABLE II
Approximate Range with Various Types of Receivers
for a Ground-based Satellite-tracking System (5 kMc)

Type of Receiver	System Noise Figure (db)	System Noise Temp (°K)	Total Noise Temp (°K)	Range (km)
Crystal Mixer	6	870	880	58,000
Uncooled parametric amplifier	1.5	120	130	150,000
Present maser	0.15	10	20	380,000
Best possible maser (estimate)	0.03	2	12	490,000
Perfect receiver	0	0	10	540,000

Discrete Sources of External Noise

The only external discrete sources of microwave radiation noise that are of practical concern are the sun and moon. If the antenna is out in space, the earth can be considered as an external discrete noise source; in this case, it should be treated as a gray body at 300°K with an angular diameter which will depend upon its distance from the antenna. Many discrete sources exist in radio stars, but the effect of these sources is not important and can usually be neglected unless they are in the main beam. As a general rule, their flux densities decrease with increasing frequency; the three largest, Cassiopeia A, Cygnus A, and Taurus A, have a flux density of approximately 10^{-23} watts/m² (cps) at 1 kMc. All of the other radio stars have a much smaller flux density.

Both the sun and moon as observed at the earth have an angular diameter of about 0.5 degrees. The contribution to the antenna temperature from these two sources varies greatly with beam position and sidelobe pattern.

Curves showing the variation of effective temperature with frequency for various discrete sources of radiation are given in Figure 1. These curves are based on estimates of average values for flux densities from highly variable

sources²; for example, if the moon is treated as a black body, it has a radar temperature which varies from 150° to 240°K, depending on its phase. Radar noise emitted by the sun can vary by two orders of magnitude from the quiet-sun condition through the noise-storm condition to the solar-outburst condition. Plots of the few available measured flux densities of the sources² indicate the following trends.

Source	Flux Density	Antenna Temperature	Remarks
Sun	$\propto f^{0.75}$	$\propto f^{-1.25}$	Normal Condition
Moon	$\propto f^2$	$\propto \text{constant}$	Typical Black-body variation
Star	$\propto f^{-0.5}$	$\propto f^{-2.5}$	Two major sources

The antenna-noise-temperature contribution varies as $f^{-2} \propto \lambda^2$ because it depends on the effective area of an antenna under conditions of constant gain.

To use these curves, the db gain over isotropic radiation of the antenna pattern in the direction of the source must be known or estimated. The large first-order sidelobes in the normal pattern lie near the main beam, and we can assume that under most conditions these will not be pointed at the sun. As an example, let us assume an X-band antenna with a main beam which is 50 db above isotropic radiation. A secondary sidelobe which is 40 db down from the main beam will then be 10 db above isotropic radiation. If one of these sidelobes is pointed at the sun, then, by looking at the 10-db curve for the sun at 10 kMc, we see that the sun will contribute about 5°K to the antenna temperature.

Whether these discrete sources should be considered depends upon the application. In general, for an antenna with good directivity the noise contributions can be neglected, provided that the source is not in the main beam or in close-lying sidelobes. In any case, as the sidelobe scans over the source, there is only a transitory increase in the antenna noise. For such applications as tracking a sun or a moon probe, a separate, careful analysis of the problem will be necessary.

Continuous Sources of External Noise

In addition to the discrete sources of noise discussed in the last section, continuous Jansky noise is emitted by the galaxy. The effective temperature of the radiation has both a directional and frequency (f) dependence; it reaches a maximum when the receiver is pointed toward the center of the galaxy, and it decreases as $(f)^{2.5}$. Plots of the

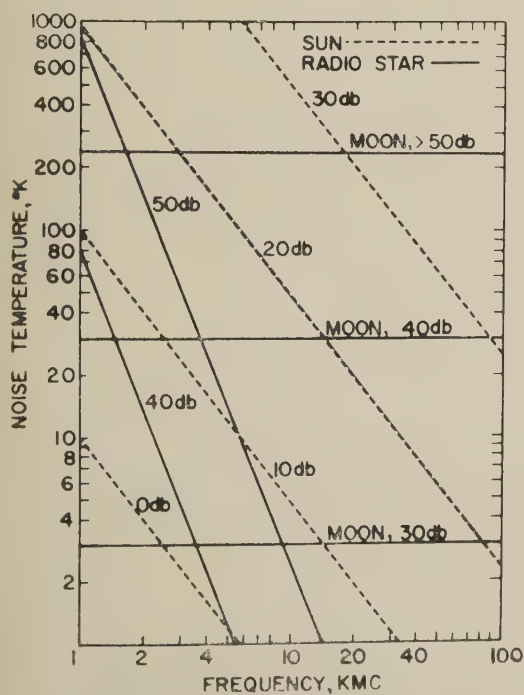


Figure 1 — Discrete sources of external noise.

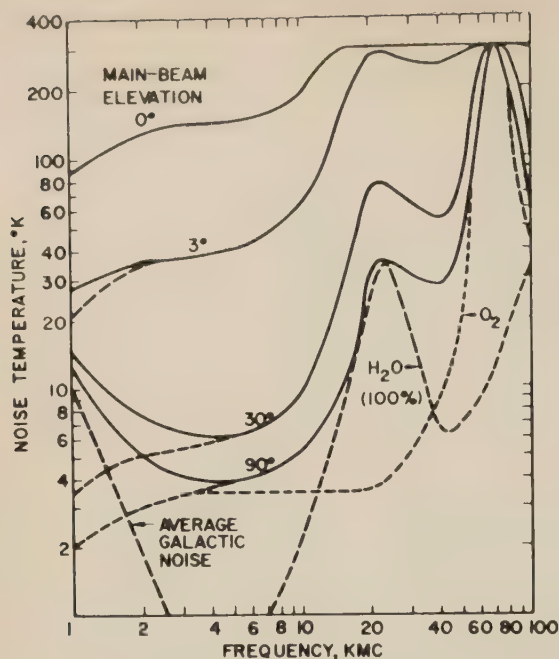


Figure 2 — Contribution to antenna temperature from galactic and atmospheric emission (ground-based antenna, 100 per cent humidity).

average galactic noise temperature as a function of frequency are included in Figures 2 through 4.^{3, 4} The data are in each case reduced so that they represent the results from an idealized antenna system with a pencil beam and no side- or backlobes. Because of atmospheric absorption, no data are available for frequencies greater than 10 kMc, but it is assumed that the galactic noise continues to decrease at higher frequencies.

In the earth's atmosphere, absorption of oxygen and water vapor accounts for most of the external noise, especially at the higher frequencies where absorption peaks occur (>20 kMc). The noise due to the combined effects of water-vapor and oxygen absorption is plotted in Figures 2 and 3 for two antenna altitudes and various beam attitudes. The data from which these curves are derived were obtained from calculations made on the basis of well-known atmospheric-absorption curves that have been verified experimentally.^{3, 8, 10} The total attenuation from the antenna to outer space has been calculated on the assumption of a spherically layered atmosphere with standard oxygen⁵ and saturated water-vapor gradients. The contribution of water vapor to attenuation is negligible above an altitude of 12 km. Figure 2 does not agree exactly with reference 8 Figure 1, and reference 10, Figure 9, since slightly different atmospheric models and average galactic noise levels were assumed.

The antenna noise temperature due to the atmosphere has been calculated by assuming that the absorbing layers, besides reducing the galactic noise slightly, also emit thermal microwave noise that has an equivalent temperature proportional to the emissivity times the physical temperature, or, in terms of loss,

$$T_A = T_P (1 - 1/L) + T_{GAL}/L \quad (9)$$

where L is the loss ratio.

The physical temperature of the ICAO standard atmosphere⁵ starts at 289°K at ground level and drops to 217°K at approximately 15 km. In calculating the approximate curves in Figure 2, a rough approximation to

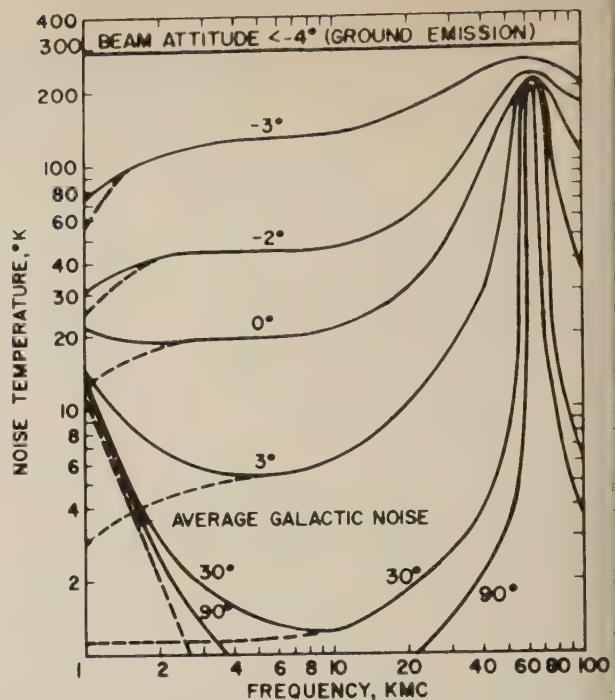


Figure 3 — Contribution to antenna temperature from galactic and atmospheric emission (altitude = 50,000 ft = 10 miles = 16 km).

the ICAO standard atmosphere was made by assuming 300°K for high attenuation rates and 250°K for low attenuation rates. For the high-altitude case, where we are looking above the horizontal, the physical temperature was assumed to be 220°K.

For completeness, the effect of relative humidity on the contribution of galactic and atmospheric emission to antenna temperature is shown in Figure 4 for a ground-based antenna with vertical elevation. As would be expected, the principal change occurs in the region between 10 and 40 kMc, i.e., the region of the principal water absorption band.

From curves illustrating the combined noise-temperature contributions from both galactic and atmospheric emission, it is possible to find the frequency range in which the noise is a minimum. By studying Figures 2 through 4, it can be seen that this "window" is a function of antenna altitude, beam elevation, and humidity. In general, for vertical beams the lower end of the window is about 3 kMc; the upper end of the window varies with different conditions, being 7 kMc for low altitude and high humidity, 10 kMc for low altitude and low humidity, and 20 kMc for high altitudes (above most of the water vapor).

When the results of these curves are applied to system design, it must be borne in mind that the atmosphere affects the signal as well as the noise. In addition to its thermal noise emission, the atmosphere also attenuates the signal. If the system is being operated at a frequency in a range for which the atmospheric attenuation of the signal is appreciable, a separate, specific, analysis will be necessary.

Other continuous sources of external noise, which must be considered by the systems designer, are jamming and ground clutter. The problem of jamming is of interest only for military applications, and cannot be discussed in detail because of security restrictions. However, because

of the nature of the electronic-countermeasure and counter-countermeasure tactical situation, it is well to bear in mind that other factors, as well as the noise characteristics of the receiver, are important, and must be considered before the proper choice of amplifier can be made.

For the airborne search-radar application, the power levels from ground clutter received through sidelobes are intolerably high, on the order of 10^5 to 10^6 °K as expressed in terms of noise temperature. However, it is relatively easy to cancel such interference; the most advanced techniques using crystal filters are able to achieve a reduction of 80 db. Therefore, the noise contributed by ground clutter will not be considered further in this paper.

Calculation of Maximum Range

The minimum detectable signal power $S_{\min}$ can be expressed in terms of the range equation, which allows one the advantage of calculating the variation in maximum range $R_{\max}$ for a given target as a function of external and internal noise power. Equations (10) and (11) are, respectively, the usual range equations for the radar case and one-way communication case.

$$S_{\min} = \frac{P_T G_T^2 \lambda^2 \sigma}{(4\pi)^3 R_{\max}^4} \quad (10)$$

$$S_{\min} = \frac{P_T G_T A_R}{4\pi R_{\max}^2} \quad (11)$$

where

P_T = transmitted power

λ = wavelength

G_T = gain of the transmitting antenna

σ = cross-sectional area of the radar target

A_R = area of the receiving antenna.

If the maximum radar range $R_{\max}$ is the range for which the equality sign holds in (3), then combining (3) and (10) and solving for the range leads to the desired relation:

$$R_{\max} = \left[\frac{P_T G_T^2 \lambda^2 \sigma}{(4\pi)^3 \text{ kBX}} \cdot \frac{1}{(T_A + T_R)} \right]^{1/4} \quad (12)$$

Let R_0 be the maximum range at which a radar with an effective receiver temperature of 0°K with no external nontarget sources and an effective antenna temperature of 290°K can detect a target of cross section σ . All other radar parameters are the same as above. Then

$$R_0 = \left[\frac{P_T G_T^2 \lambda^2 \sigma}{(4\pi)^3 \text{ kBX}} \cdot \frac{1}{290} \right]^{1/4} \quad (13)$$

and a normalized radar range is given by

$$\frac{R_{\max}}{R_0} = \left[\frac{290}{(T_A + T_R)} \right]^{1/4} \quad (14)$$

In the same manner, we can obtain a normalized one-way communication range that is given by

$$\frac{R_{\max}}{R_0} = \left[\frac{290}{(T_A + T_R)} \right]^{1/2} \quad (15)$$

The only difference between (14) and (15) is in the fractional exponents on the temperatures.

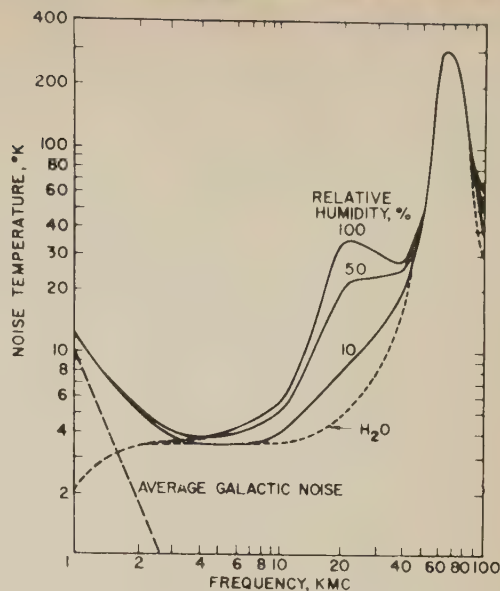


Figure 4 — Contribution to antenna temperature from galactic and atmospheric emission (ground-based antenna, vertical elevation); change with relative humidity.

To obtain the equivalent noise temperature of a receiver, given its noise figure,* one uses the relation

$$T_R = (F_s - 1) 290^\circ\text{K} \quad (16)$$

Equation (14) is plotted in Figures 5 and 6, and (15) is plotted in Figures 7 and 8. Figures 5 and 7 will be most useful for estimates concerning present-day systems operating in the earth's atmosphere, whereas Figures 6 and 8 are extensions applicable only to very low-noise systems operating in a very low-noise environment.

Evaluation of the Effects of Lowering Receiver Noise

By examining Figures 5 through 8 or Equations (14) and (15), one can see that the system performance cannot always be significantly improved merely by lowering the receiver noise temperature. If this temperature is much lower than the external noise temperature, then the maximum range is determined almost entirely by the external noise, and lowering the receiver noise has little effect on system performance. If the receiver noise is approximately the same as the external noise, however, the radar system will achieve only 85 percent of its possible range performance. The communication system under the same conditions will achieve only 70 percent of its maximum possible range. The maximum possible range is defined as the range achievable when the receiver noise temperature is absolute zero. Therefore, by lowering the receiver noise temperature below that of the external noise temperature we can improve the system performance by 10 to 25 percent, which is a significant amount.

To obtain a general relation for the value of lowering receiver noise temperature, we express the receiver noise temperature as a percentage of the external noise temperature:

$$T_R = (p/100) T_A \quad (17)$$

For a given external noise temperature, as we lower the contribution of the receiver noise to the total noise, the system range increases slowly to the maximum range. The effect on the range is given by, for the radar case,

* The IRE definition of noise figure.

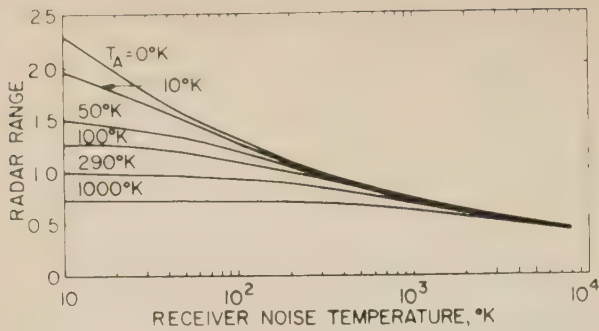


Figure 5 — Radar range (normalized to $T_A + T_R = 290^\circ\text{K}$).

$$R = \left[\frac{290}{\left(1 + \frac{P}{100}\right) T_A} \right]^{1/4} \quad (18)$$

and by, for the one-way communication case,

$$R = \left[\frac{290}{\left(1 + \frac{D}{100}\right) T_A} \right]^{1/2} \quad (19)$$

Equations (18) and (19) are plotted as percentages in Figure 9. From this graph it is easily seen that significant improvement in system range can be obtained by lowering the receiver noise temperature to about 10 to 20 percent of the external noise temperature.

Estimation of Antenna Noise: Applications

Ground-Based Satellite-Tracking Station

For a ground-based satellite-tracking station, the line of sight will be assumed to be vertical; the optimum operating frequency can be chosen by reference to Figure 2, which shows that under these conditions the continuous external noise reaches a minimum at about 5 kMc. The antenna will be assumed to be 80 meters in diameter. With the operating frequency and antenna diameter fixed, the antenna gain and half-power beamwidth can be cal-

$$R_0 = \left[\left(\frac{P_T G_T A_R}{4\pi k B} \cdot \left(\frac{1}{T_A + T_R} \right) \right)^{1/2} \right] = \left[\left(\frac{0.1 \times 1.6 \times \pi \times 40^2}{4\pi \times 1.4 \times 10^{-23} \times 10^6} \right) \cdot \left(\frac{1}{290} \right) \right]^{1/2} = \sim 10^5 \text{ km.} \quad (20)$$

culated. These are 70 db and 0.05 degrees, respectively.

The antenna noise contributions from the ground and other external sources can be obtained in the following way. Assume that continuous tracking is not necessary so

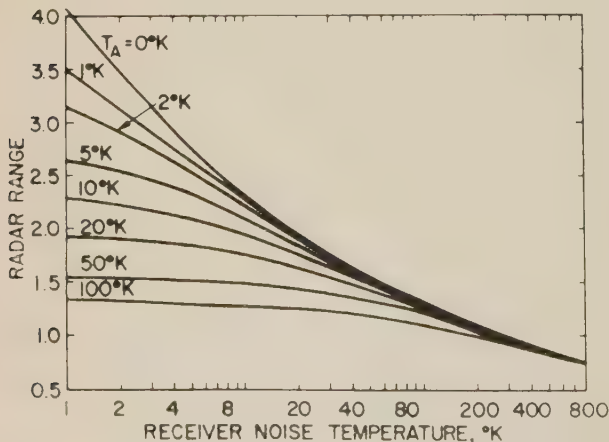


Figure 6 — Radar range (normalized to $T_A + T_R = 290^\circ\text{K}$).

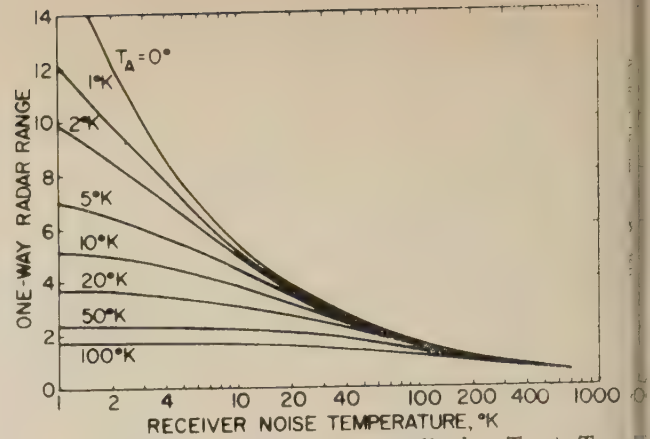


Figure 7 — One-way radar range (normalized to $T_A + T_R = 290^\circ\text{K}$).

that temporary interference by the sun and moon can be neglected. The noise contribution from the sidelobes and backlobes directed toward the ground can be considerably reduced by employing a wire-screen ground plane, which shields the antenna from the earth. For this calculation value of 0.9 for the ground-plane reflectivity will be assumed.

Because of practical difficulties, according to R. C. Hansen⁶, approximately 85 percent of the total power radiated by a microwave antenna is in the main beam regardless of dish size, and 15 percent in the sidelobes. Assume that only 1 percent of the available power is absorbed by the dish. Applying the above numerical values to Figure 2 and Equation (8), one can make the following approximate estimate of the antenna temperature to be expected in this situation, as is shown in Table I.

If a S/N ratio of one is assumed, the one-way range of such a system with a 2.94-db noise figure receiver ($T_A + T_R = 10 + 280 = 290^\circ\text{K}$) tracking a satellite which is emitting a 0.1-watt signal with a 1-Mc bandwidth from a dipole antenna $G_T = 1.6$ is

This is the standard range for this system and is to be used in conjunction with Figure 8 or Equation (15) to obtain the actual system range. The approximate range for this system with various types of receivers is illustrated in Table II.

High-Altitude Airborne Search Radar

In this application it will be assumed that we are looking horizontally through the upper atmosphere (50,000 feet) in a search for enemy aircraft or missiles. The measured pattern for a typical advanced, X-band airborne antenna was used in combination with Figure 3 in a rough numerical integration of (8) to calculate the expected antenna temperature. At an altitude of 10 miles, the tangent to the earth is at approximately -4° degrees from the horizontal, so that the main lobe, which has a half-power beamwidth of 2.0 degrees and first nulls at $\pm 3^\circ$ degrees, is above the horizon. About 80 percent of the power is in the main beam, which is looking at an area of sky that has temperatures around 10° to 50°K . In the particular pattern used, the only sidelobes that were above isotropic were the first sidelobes, which were close

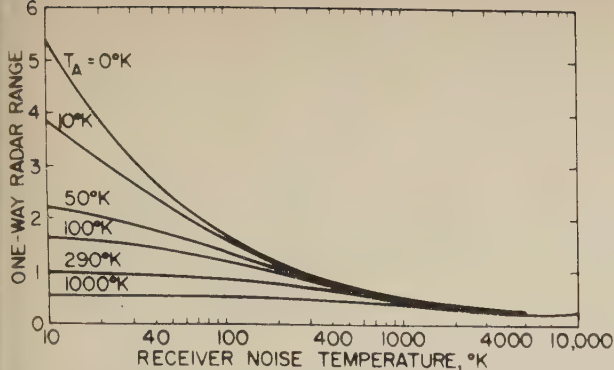


Figure 8 — One-way radar range (normalized to $T_A + T_R = 290^\circ\text{K}$).

to the main beam and which therefore were also for the most part looking at the same area of the sky. As with any present airborne system, the radome losses contribute a large amount to the total antenna temperature. A brief summation of the various contributions to be expected for a high-altitude airborne search radar for the horizontal scan mode is given in Table III.

This calculated antenna noise temperature will, of course, vary considerably with beam elevation, especially as the beam is directed downward. Some rough estimates of this dependence on beam elevation are given in Table V.

We will now calculate the range of the airborne search radar on a typical target when various receivers are used.

$$R_{\max} = \left[\left(\frac{P_T G_T^2 \lambda^2 \sigma}{(4\pi)^3 \text{ kBX}} \right) \cdot \left(\frac{1}{T_A + T_R} \right) \right]^{1/4} \quad (21)$$

We will assume the following values for a typical application:

- $P_T = 10^5$ watts $B = 10^6$ cps
- $G_T = 5 \times 10^3$ $K = 1.4 \times 10^{-23}$ joules/°K
- $\lambda = 0.03$ m $X = 3$.
- $\sigma = 1$ m²

In order that we may use Figure 5, we will calculate a standard radar range by letting $(T_A + T_R) = 290^\circ\text{K}$.

We will now obtain the maximum range by using an estimated antenna noise temperature of 67°K and various

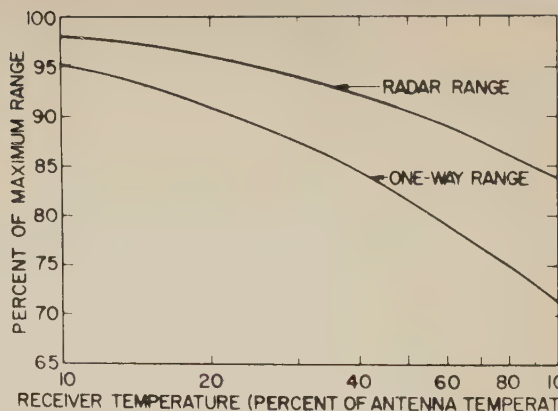


Figure 9 — Per cent of maximum theoretical radar range obtainable when the receiver noise temperature is less than the antenna noise temperature.

different receivers. In a practical airborne radar system, we must include in our calculations the system losses ahead of the receiver, such as those from the TR tube and rotary joints. We will assume that they will amount to 0.45 db ($L = 1.11$). If they occur at 300°K , these losses are equivalent to a noise of $(L - 1)T_s = (1.11 - 1)300 = 33^\circ\text{K}$. This must be added to the amplifier noise temperature to get the total effective receiver noise temperature. The estimated ranges, which can be calculated from (14) or read from Figure 5, are given in Table V.

From this table, we see that we can increase our range 68 km by replacing the crystal mixer with a good uncooled parametric amplifier; if we replace the parametric amplifier with a presently available maser, we can increase the range by another 21 km. Note, however, that we cannot continue to increase the range by lowering the receiver noise, since the range is now limited by the other noise sources. Some of these noise sources could conceivably be reduced in future systems, and any decrease will show up directly as an increase in maximum range. For instance, if the radome noise temperature could be reduced from 20°K to 2°K and the system losses from 33°K to 8°K , then the total equivalent antenna noise temperature would be about 60°K ; under these conditions we would have a range of 143 km.

$$R_0 = \left[\left(\frac{10^5 \times 25 \times 10^6 \times 9 \times 10^{-4}}{(4\pi)^3 \times 1.4 \times 10^{-23} \times 10^6 \times 3} \right) \cdot \left(\frac{1}{290} \right) \right]^{1/4} \approx 100 \text{ km.} \quad (22)$$

TABLE III
Sample Calculation for the Estimate of Antenna Temperature for a High-altitude Airborne Search Radar (9 kMc)

Portion of the Beam	$G_i \frac{\Delta \theta_i}{2\pi}$	Atmospheric Emission (°K)	$G_i T_i \frac{\Delta \theta_i}{2\pi}$ (°K)
Main beam	0.76	29	22
First sidelobes	0.10	120	12
Other lobes	0.09	145	13
Radome Losses			5% x 400°K
			$\sum G_i T_i \frac{\Delta \theta_i}{2\pi} = 47^\circ\text{K}$
			$\frac{20^\circ\text{K}}{67^\circ\text{K}}$

TABLE IV
Dependence of Estimated Antenna Noise Temperature
on Beam Elevation for a High-altitude Airborne
Search Radar (9 kMc)

Beam Elevation (degrees from horizontal)	Estimated Antenna Noise Temperature (°K)
< - 4	250
- 3	170
- 2	120
- 1	85
0	67
+ 1	60
+ 2	50
> + 5	40*

* Limited by radome and sidelobe contributions.

TABLE V
Approximate Range with Various Types of Receiver
for a High-altitude Airborne Search Radar

Receiver	T _R Amplifier Noise Temp. (°K)	Total Effective Receiver Noise Temp. (L-1)T _s + LT _R	Total Noise Temp. (L-1)T _s + LT _R + 67	Range (km)
Crystal Mixer	870	999	1066	38
Uncooled para- metric amplifier	120	166	223	106
Present maser	10	44	111	127
Future maser (estimated)	2	35	102	130
Perfect receiver	0	33	100	132

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ELECTROSTATIC FOCUSING of MICROWAVE TUBES

J. R. HECHTEL

MICHELSON LABORATORY

U. S. NAVAL ORDNANCE TEST STATION

China Lake • California

LAST OF TWO PARTS

PERIODIC FIELDS

Systems for Focusing Solid Beams

The "Einzel-lens" has been shown to be capable of compensating for space charge effects in a short electron beam. The idea of employing a succession of Einzel lenses for a long beam suggests itself. There are several possibilities for realizing this idea. A very simple arrangement consists of equally spaced annular disks or rings at alternatively high and low potentials (Figure 16). Another method makes use of the d.c. field of a bifilar helix with a potential difference between the two helical wires. Quadrupolar fields, which have been used in accelerators, probably offer no advantage in microwave tubes. In this case the shape of electrodes is not easy to combine with an r.f. structure.

A theoretical treatment of periodic electric focusing was given by Clogston and Heffner [11], Barnes [12], Tien [13], Pierce [15], Siekanowicz and Vaccaro [16]. For simplification, a series of assumptions and neglects have to be made. One of these assumptions is that the potential V varies sinusoidally in z -direction according to

$$V = V_0 + V_1 I_0 \left(\frac{2\pi r}{p} \right) \sin \frac{2\pi z}{p}$$

where I_0 is the zero order modified Bessel function of the first kind and p the period of the system. This means that only the first two terms of the series expression for the potential

$$V = V_0 + \sum_n V_n I_n \left(\frac{2\pi nr}{p} \right) \sin \frac{2\pi nz}{p}$$

are used. Another assumption commonly made is that V_1 , the focusing voltage, is small compared to the average beam voltage V_0 . In spite of these simplifications, the calculations are quite complicated and the result is not always of a form amenable to an easy and immediate interpretation. As some of the assumptions are not very well fulfilled in a focusing system for a high perveance electron beam, it is difficult to estimate the value of the results for the tube designer.

With regard to the complexity of theory, only some of the more important results can be given here. The first is that for certain initial conditions essentially parallel electron flow can be maintained. The electron beam scallops with a small amplitude and a spatial period equal to that of the focusing structure. In regions where the potential is low the electrons are close to the focusing structure and vice versa.

Consider a focusing system consisting of annular rings or disks. If the average beam diameter d is small compared to the period p , the perveance can be calculated approximately from

$$P \approx 61 \times 10^{-6} \left(\frac{V_1}{V_0} \right)^2 \left(\frac{d}{p} \right)^2 \frac{\text{amps}}{\text{volts}^{3/2}} \quad (14)$$

where V_1 is the focusing voltage. The current density is constant over the cross section of the beam in this case. In order to achieve a high perveance with a certain beam diameter, the focusing voltage V_1 has to be large and the period p small. However Equation 14 is not too well suited for calculating the maximum attainable perveance as it was derived under the assumption $V_1 \ll V_0$ and $d \ll p$. Let us assume $V_1 = 0.5 V_0$ and $d = 0.5 p$, hoping that Equation 14 still gives a reasonably accurate result. The perveance of 3.8×10^{-6} amps/volts^{3/2} which is calculated from these values is well

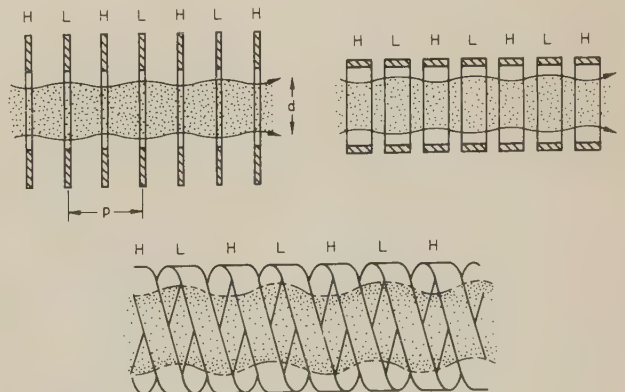


Figure 16 — Focusing systems for solid beams

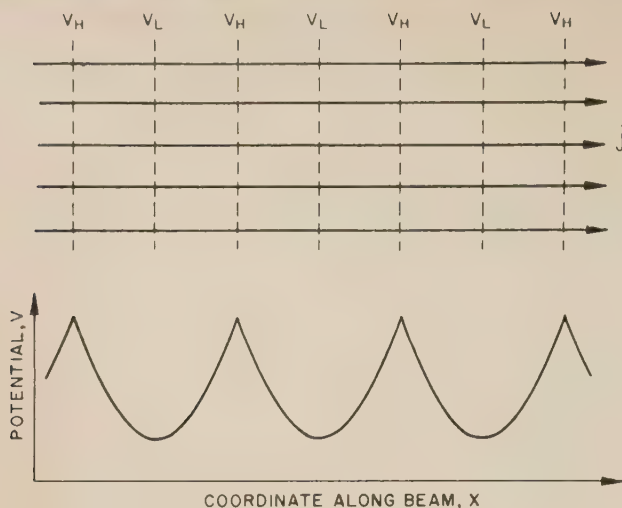


Figure 17 — Potential distribution in an electron stream with grids at alternately high and low potentials

within the range of interest for microwave tubes.

For values of the beam radius r_0 , comparable to the period p , the current density must increase towards the edge of the beam if parallel electron flow is to be maintained over the whole cross section. This fact may be regarded as a consequence of the spherical aberration of the focusing system. For the rather complicated formula giving the space charge density as a function of the radius, reference should be made to Tien's paper [13]. Tien also treats the bifilar helix as a periodic focusing structure and gives an example of the radial current density distribution. In such a system the current density on the axis is approximately zero.

In a traveling wave tube or backward wave oscillator, the bifilar helix can act at the same time as a delay line and as a focusing structure.

This principle has been used in backward wave oscillators by Tien [13, 14], and by Ayers and Evans [17], and recently in a traveling wave tube by Blattner, Vaccaro, Cuccia and Johnson [18].

Tien reports a maximum beam transmission of 78 per cent with beam and focusing voltages of 480 volts and a current of 1 ma. These values give a perveance of 0.1×10^{-6} amps/volts^{3/2}. Oscillations were observed at frequencies between 3 and 3.5 kmc.

The backward wave oscillator of Ayers and Evans was designed for X-band and delivered a maximum r.f. power of 20 mw with a beam voltage from 250 to 1300 volts. Instead of a beam with the theoretically required current density distribution, Ayers and Evans had an electron gun which produced a hollow beam. Without a center conductor, no space charge force exists at the inner edge of the beam, so that the focusing force will push the inner electrons towards the axis until equilibrium between space charge and focusing forces is restored. From these considerations it might be concluded that the original current distribution within the beam is not too important. Indeed a current distribution different from the ideal case does not affect the edge of the beam, but leads to radial oscillations of the electrons within the beam.

The traveling wave tube of Blattner, Vaccaro, Cuccia and Johnson was designed for a frequency range from

approximately two to 3.5 kmc. In an experimental tube a beam transmission as high as 99.2 per cent without and 98.5 per cent with r.f. was achieved. The beam voltage was 2000 volts, the focusing voltage V_H had approximately the same value, and the current was 50 ma. The perveance, calculated from the beam voltage is 0.56×10^{-6} amps/volts^{3/2}. At a frequency of 3 kmc a saturation power of 21 w was measured, which equals a gain of 23 db. Assuming the collector voltage to be the same as the beam voltage, the efficiency of the tube is 20 per cent. The electron gun of this tube produces a beam of approximately constant current density over the cross section. Similar to the case of the hollow beam, the current distribution will change within the focusing system, causing radial oscillations of the electrons.

Hergenrother and Bowers [19], in their backward wave oscillator, have an interdigital line which is divided into two isolated parts, so that successive fingers can be connected to different d.c. voltages. The center portion of each finger is expanded into a circular aperture for the electron beam. Similar to Ayers' tube, an initially hollow beam is employed. This tube has a frequency range from one to two kmc with an average r.f. power of 1 w and an efficiency of about 5 per cent.

A new approach to the problem of focusing a high perveance electron beam was made by Siekanowicz and Vaccaro [16]. Their method is similar to that used in the design of a Pierce gun. Consider an electron stream of homogeneous current density J infinitely extended normal to the x -direction. Within this stream a series of grids is arranged, as shown in Figure 17. These grids have alternatively high and low potentials V_H and V_L . For a certain current density the gradient of the potential at the low voltage grids will be zero. Then the potential distribution is given by

$$x/x_0 = \left(\sqrt{\frac{V(x)}{V_L}} + 2 \right) \left(\sqrt{\frac{V(x)}{V_L}} - 1 \right)^{1/2} \quad (15)$$

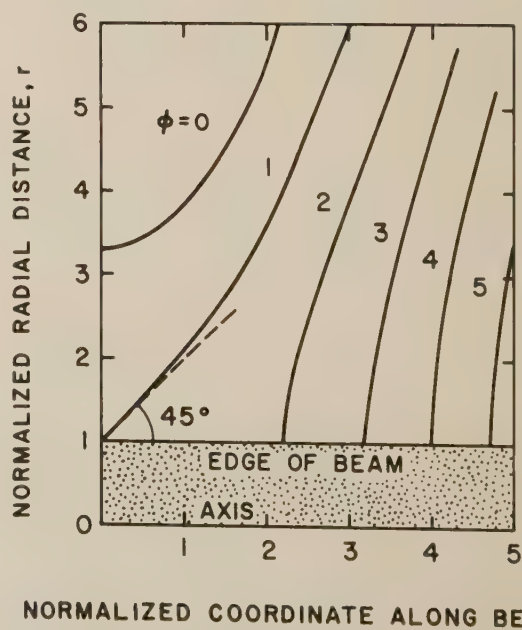


Figure 18 — Potential distribution outside a beam having rectilinear electron flow

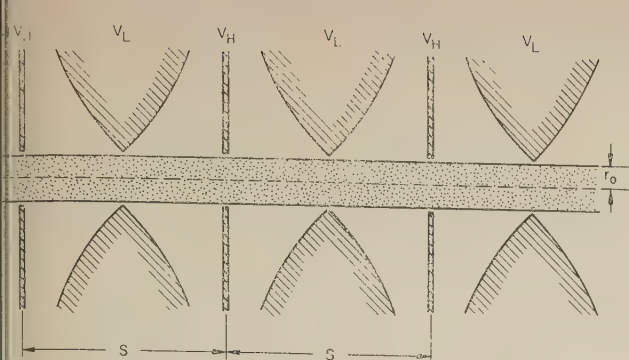


Figure 19—Axially symmetric system for producing an approximately rectilinear electron flow.

where

$$x_0 = aV_L^{3/4}/J^{1/2}$$

and

$$a^2 = 2.33 \times 10^{-6} \text{ amps/volts}^{3/2}$$

Now the same arrangement but an electron beam of finite transverse cross section will be considered. In order to maintain rectilinear electron flow the potential distribution at the edge of the beam must be the same as given by Equation 15. This is only possible if the potential distribution in the region outside the beam, which is now free of space charge, is changed. The new, unknown potential distribution can be found by means of an electrolytic tank or by numerical calculations based on Laplace's equation. Figure 18 shows the result of this calculation for a beam of circular cross section. The equipotentials of Figure 18 determine the shape of the electrodes which are necessary to maintain the required potential distribution at the edge of the beam.

The low voltage electrode shaped as equipotential $\phi = 1$ can be replaced by a zero potential electrode shaped as equipotential $\phi = 0$. The shape of the high voltage electrodes, as seen from the low voltage side, should be convex. This is a condition which cannot be fulfilled in a periodic system where low voltage electrodes are placed on both sides of a high voltage electrode. The closest possible approach to the theoretical solution is a thin disk with an aperture for the beam, as shown in Figure 19. For a circular beam, the maximum current which can be focused in this way with a given voltage V_H is

$$I_{\max} = 14.7 \times 10^{-6} V_H^{3/2} \left(\frac{d}{p} \right)^2 \quad (16)$$

where d is the beam diameter and p the period of the system. The low voltage electrodes have in this case the voltage

$$V_L = 0.25 V_H$$

Equation 16 was derived under the assumption of ideally permeable grids at the plane of high and low potential. Of course, in a practical focusing system, grids cannot be used. Eliminating the low potential grids does not change the potential distribution because the gradient of potential is zero. However omission of the high potential grids produces the effect of diverging lenses. The lenses not only disturb the ideal rectilinear electron flow, but also reduce the maximum focusable

current given by Equation 16. The effect is more pronounced as the ratio of beam diameter d to the period p increases. Therefore Equation 16 is only valid for $d \ll p$. For larger values of d , both Equation 14 and Equation 16 give too high values of the current or perveance.

It is interesting to compare Equation 16 to Equation 14, which was derived in an entirely different way. For

$$\frac{V_L}{V_H} = 0.25 \text{ the potentials must have values of:}$$

$$V_1 = 0.6 V_0$$

$$V_H = V_0 + V_1 = 1.6 V_0$$

$$V_L = V_0 - V_1 = 0.4 V_0$$

If the current is expressed in terms of V_0 , we find from Equation 14

$$I_{\max} = 11 \times 10^{-6} (d/p)^2 V_0^{3/2} \quad (14a)$$

This is a remarkably good agreement between the two values for $I_{\max}$.

The following experimental data were given by Siekanowicz and Vaccaro:

$$d/p = 0.31$$

$$V_H = 850 \text{ volts}$$

$$V_L = 260 \text{ volts}$$

$$\text{Effective voltage } V_{\text{eff}} = 445 \text{ volts}$$

$$I = 30 \text{ ma}$$

$$I/V_{\text{eff}}^{3/2} = 3.2 \times 10^{-6} \text{ amps/volts}^{3/2}$$

$$\text{Beam transmission} = 96\%$$

The effective voltage is the voltage which has to be applied to a beam of constant velocity if the transit time of electrons is to be the same as in a given periodic focusing system. Theoretically a perveance of $I/V_{\text{eff}}^{3/2} = 4.1 \times 10^{-6} \text{ amps/volts}^{3/2}$ was calculated.

Based on this new focusing scheme Belohoubek, Siekanowicz and Vaccaro [20] developed an experimental traveling wave tube with a cross-bar structure as a delay line. Between the cross-bars lens, electrodes are arranged, which are separated from the rest of the r.f. structure d.c. wise by means of chokes. As the electrodes have to produce both the r.f. fields and the electrostatic fields, the electrode shapes required for optimum focusing conditions had to be modified considerably. The electrical data of the tube are the following:

Center frequency	$f = 9.2 \text{ kmc}$
	$V_L = 10.4 \text{ kvolts}$
	$V_H = 31.6 \text{ kvolts}$
	$I = 3 \text{ amps peak}$
Beam transmission	86% = without r.f.
	76% = with r.f.
Peak power output	$P_0 = 9.8 \text{ kw}$
Large signal gain	$G = 12 \text{ db}$
Bandwidth	7%
Efficiency with depressed collector	30%

The perveance of the beam expressed in terms of the effective voltage V_{eff} is $P_{\text{eff}} = I/V_{\text{eff}}^{3/2} = 1.5 \times 10^{-6} \text{ amps/volts}^{3/2}$.

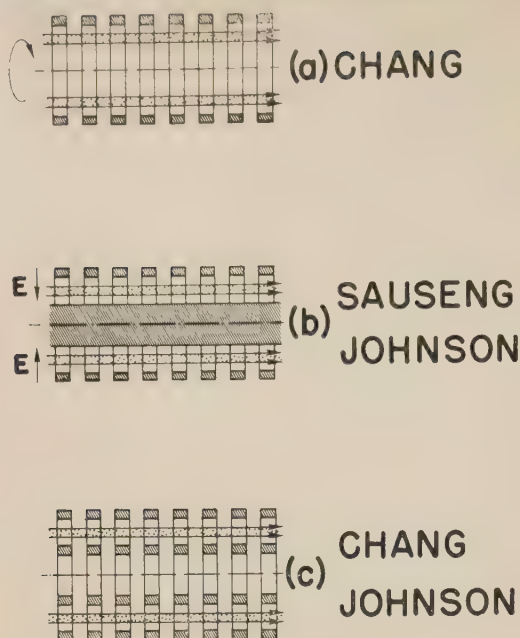


Figure 20 — Focusing schemes for hollow beams

Hollow Beams

As formerly shown, the maximum current in a solid beam grows approximately with the square of the beam diameter d . This suggests making d as large as possible. However there is a rather narrow limit, caused by the beam coupling coefficient which rapidly decreases in the center of the beam if d becomes too large. Obviously these difficulties do not exist if a hollow beam is used instead of a solid beam. In other words, higher values of perveance can be achieved without sacrificing good coupling between beam and r.f. fields.

There are several methods of focusing hollow beams by electrostatic fields. First, let us consider the case where there is no conductor in the interior of the beam. With a focusing structure outside the beam, as shown in Figure 20a, the system is not stable. To make it stable, Chang [21] proposed to use the centrifugal force of a beam rotating around the axis as an additional outward force. The rotation of the beam can be produced in a similar way as in Harris' system by a radial magnetic field in the region between gun and focusing structure. According to Chang, this system should be more stable than comparable systems such as Brillouin-flow or Harris-flow. In an experiment described by Chang, the focusing structure was a bifilar helix of 2.3 mm inner diameter and 1.9 turns per mm. The results were

Average voltage	$V_{av} = 650$ volts
Voltage difference between helices	$V_H - V_L = 700$ volts
	$I = 1$ ma
Beam transmission	95 %
Perveance	$I/V_{av}^{3/2} = 0.06 \times 10^{-6}$ amps/volts ^{3/2}

A system consisting of a periodic focusing structure outside and a conducting cylinder inside a hollow beam, as shown in Figure 20b, was proposed by Sauseng [22]. The focusing structure may be composed of a succession of rings at alternately high and low potentials V_H and V_L .

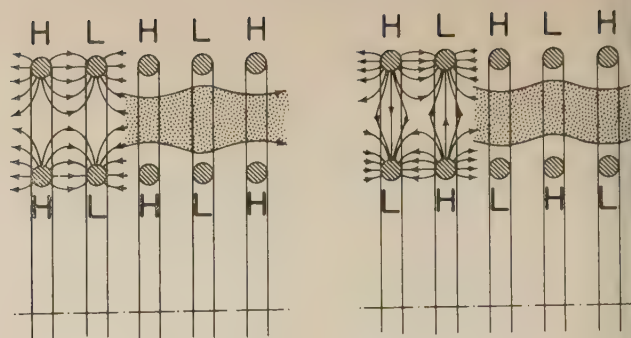


Figure 21 — Two biperiodic focusing methods for hollow beams

A voltage $V_z < 1/2(V_H + V_L)$ is applied to the inner conductor. This provides a potential trough for the electrons, causing them to move on stable paths in the space between the inner conductor and the focusing structure. The system was investigated theoretically and experimentally by Sauseng [22] and by Johnson [23]. Sauseng gave the following experimental data:

Average beam voltage	$V_B = 150$ volts
Focusing voltage	$V_H - V_L = 150$ volts
Beam current	$I = 17$ ma
Perveance	$1/V_B^{3/2} = 9.4 \times 10^{-6}$ amps/volts ^{3/2}
Beam transmission	62 %

For smaller currents, a beam transmission up to 82 per cent was observed. Johnson reports a beam transmission between 85 per cent and 97 per cent, with values of the perveance between 1.2×10^{-6} and 8×10^{-6} amps/volts^{3/2}. The average beam voltage was of the order of 400 volts. Probably the main reason for the better transmission obtained by Johnson was the higher average beam voltage. With a beam voltage of only 150 volts, as used by Sauseng, the thermal velocity of electrons causes a considerable increase in beam diameter and therefore impairs the beam transmission.

Johnson points out that both his experiments and theory indicate a remarkable insensitivity of this system to the entrance conditions. He believes that the stiffness of the beam is as good or better than that of conventional beams.

An arrangement of the focusing structure inside the beam and conducting cylinder outside should work in a manner very similar to Sauseng's method. To the author's knowledge, such an arrangement has not yet been tried.

Systems employing a focusing structure both inside and outside a hollow beam (Figure 20c) have been studied by Chang [24, 25] and by Johnson [23]. Chang has proposed the name "biperiodic electrostatic focusing" for this method. The focusing structure usually consists of a succession of rings or of bifilar helices. If both structures have the same periodicity, two possibilities for applying the focusing voltage exist. Electrodes with the same z -coordinates can have the same or opposite voltages as shown in Figure 21. Although the type of focusing and the electron trajectories are different, the net focusing action is the same in both cases, as Johnson pointed out. In the case of equal voltages we have the common lens action. With opposite voltages the focusing effect can be regarded as a mixture of deflection focusing and ordinary lens action.

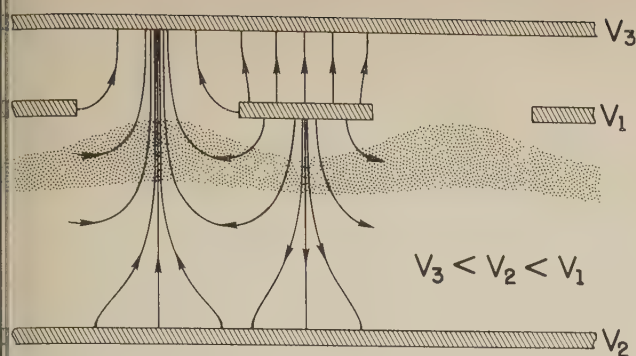


Figure 22 — Fields and beam path in a single-ladder focusing structure according to Hogg

A traveling wave tube built by Chang had bifilar helices for the inner and the outer focusing structure. The outer bifilar helix served also as a delay line. Chang gave the following data:

Average beam voltage	$V_B = 180$ volts
Focusing voltage	$V_H - V_L = 200$ volts for both bifilar helices
Beam current	$I = 4$ ma
Perveance	$I/V_B^{3/2} = 1.7 \times 10^{-6}$ amps/volts $^{3/2}$
Beam transmission	97 %
frequency	$f = 2950$ mc
r.f. power	100 mw
Gain	$G = 10$ db
Efficiency	14 %

Chang claims that in a biperiodic focusing system the potential valley for the electrons is steeper than in all other systems. This means that this system should be more stable than all known focusing methods.

Johnson theoretically compared the biperiodic system to Sauseng's method. With the same geometry (replacing one focusing structure by a cylinder), Sauseng's system needs a 40 per cent higher focusing voltage to focus the same current. The higher focusing voltage is partially compensated for by the greater simplicity of Sauseng's arrangement.

Ribbon Beams

Neglecting edge effects, the focusing of a ribbon beam represents a two-dimensional problem. Three systems have been used.

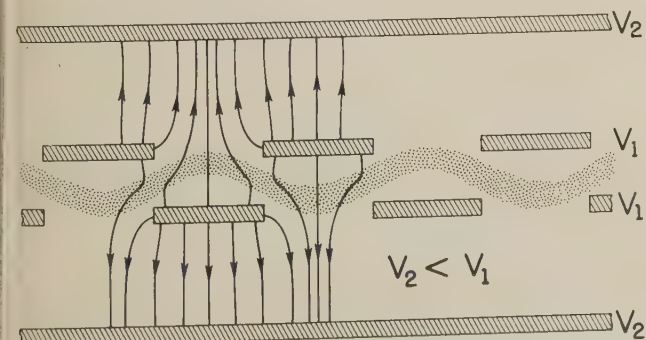


Figure 23 — Fields and beam path in a double-ladder focusing structure according to Hogg

1) A succession of electrodes on both sides of the beam at alternately high and low potentials. This is the equivalent of Chang's biperiodic focusing scheme. Backward wave oscillators with an interdigital line as a slow wave structure are especially suitable for this system. The delay line is divided into two parts which are connected to different potentials, so that the fingers are at alternately high and low potentials. Tubes of this kind with a frequency range of more than one octave have been developed by Charles and Gentner of C.S.F., Paris. [26]

2) An ingenious version of deflection focusing was proposed and tried by Hogg [27]. Hogg developed two new focusing schemes for backward wave oscillators, the "single-ladder" and the "double-ladder" structure (Figure 22 and 23). The main advantage of these systems is that the whole r.f. structure has the same d.c. potential. The periodic focusing fields are produced by additional electrodes surrounding the r.f. structure.

The maximum beam transmission obtained with the single-ladder was 50 per cent and 70 per cent with the double-ladder structure. The beam voltage was in both cases 750 volts, the perveance 0.5×10^{-6} amps/volts $^{3/2}$. A backward wave oscillator with a single-ladder delay line was tunable from 1.4 to 2.3 kmc, another one with the double-ladder from 1.4 to 2.6 kmc. The power output was of the order of 100 mw according to Hogg. The entrance conditions for the beam are very critical in these systems.

3) Kompfner proposed a system, called slalom focusing [28, 29], which consists of an array of positive rods or wires placed midway between two negative plates as shown in Figure 24. An electron beam injected with the right entrance conditions, weaves sinusoidally through the wires without hitting them. The wires or rods can, at the same time, be part of an r.f. slow wave structure. As Cook, Kompfner, and Yocom have shown, the electrons in such a system follow an equipotential. This focusing scheme is somewhat similar to Hogg's single-ladder structure, the main difference being that in Hogg's system the beam is always on the same side of the slow wave structure.

In a beam testing experiment, Cook, Kompfner, and Yocom measured a beam transmission of 97 per cent with a perveance of 2×10^{-6} amps/volts $^{3/2}$. With a perveance of 4.2×10^{-6} , the transmission was still 92 per cent and decreased to 48 per cent with a perveance of 12.7×10^{-6} . The beam voltage had the relatively low value of 265 volts.

The beam transmission was only 15 per cent in a backward wave oscillator for the frequency range from 3.3 to 4.3 kmc. Poor injection conditions were believed to be responsible for the low transmission in this case.

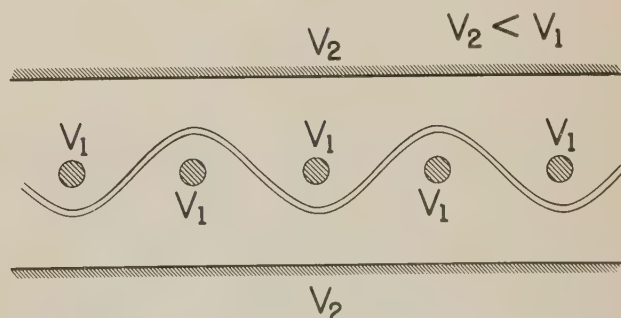


Figure 24 — Slalom-Focusing of a ribbon beam

The three methods described here are not the only possible ones to focus a ribbon beam. For example, Sauseng's method can be used in connection with a ribbon beam as well as with cylindrical systems.

4. CONCLUSIONS

Electrostatic focusing in microwave tubes offers significant advantages. Compared to commonly used magnetic focusing, it saves weight, space, and energy and thus improves the overall efficiency of tubes. External stray fields are non-existent, and the focusing is independent of temperature. Noise properties and the cathode lifetime are improved because ions are rapidly drained by strong electric fields.

A large number of focusing schemes has been proposed or tried out with varying success. At present it is difficult to explain the differences in performance between different systems. In most cases poor beam entrance conditions are believed to be responsible for a low beam transmission.

The first electrostatically focused backward wave oscillators and medium power traveling wave tubes have been successfully tested. Little work has been done with electrostatically focused klystrons.

Theories have been developed to explain the properties of the different focusing schemes. However, in most existing theories too many simplifying assumptions have

been made to permit quantitative predictions. Therefore the design of focusing systems is largely empirical. For better understanding of existing systems and achieving further progress, more theoretical work is necessary. Electron optics, including space charge effects, is still in a very rudimentary stage. In nearly all cases, problems are too complex to allow for analytical solutions. Analog computers, such as the electrolytic tank or the resistor network, have proved to be the most powerful instrument for solving these problems. Of course no general solution can be obtained in this way. The design of individual systems with optimum properties is time consuming. Compared to the time required for the design of a well-corrected light optical system, this procedure seems entirely reasonable and justified. The most important future problems are probably the development of better electron guns with less aberration, and a careful study of the region between gun and focusing system.

Much work is being done on electrostatic focusing for microwave tubes and the development in this field is rapid. There is no reason why a well designed electrostatic system should not equal or be superior to the best existing magnetic systems.

ACKNOWLEDGEMENT

The author wishes to thank Mr. D. A. Watkins for the use of the diagram of the helitron in Figure 13.

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CONTROL OF THE AMPLITUDE AND PHASE OF AN ELECTROMAGNETIC WAVE IN A WAVEGUIDE BY MEANS OF A GERMANIUM PLATE[†]

N. V. ALEKSANDROV
E. M. GERSHENZON

L. B. GORSKAYA
V. S. ETKIN

Gunn and Hogarth¹ described an attenuator for centimeter waves, using the dependence of the absorption of electromagnetic waves by free carriers in germanium on the concentration of the carriers. Later on, this note was cited many times in surveys (see, for example,^{2, 3}), but no new data were found on the use of similar devices in the microwave band. At the same time, this problem is of interest because of the concentration of free carriers influencing not only the conductivity, which determines the absorption of the electromagnetic wave, but also the dielectric constant of the semiconductor.

Actually, the conductivity and dielectric constant of a semiconductor are given by the relations ^{4, 5} **.

$$\sigma = \frac{e^2 N \tau}{m^* [1 + (\omega \tau)^2]} ; \quad \epsilon = \epsilon_1 - \frac{4\pi N e^2 \tau^2}{m^* [1 + (\omega \tau)^2]}$$

where e is the charge of the electron, N the number of carriers per unit volume, τ the time of carrier mean free path, m^* the effective mass of the carrier, ω the radial frequency of the electromagnetic field, and ϵ_1 the dielectric constant of the crystal lattice, determined by the bound charges.

Experimental investigations have shown^{6, 7, 8}, that the contribution of the free carriers to the dielectric con-

In the present investigation we studied the possibility of phase and amplitude modulation of an electromagnetic wave incident on a germanium plate, located across a waveguide, by varying the concentration of the free carriers.

The concentration of carriers was controlled by using the Hall effect in the germanium plate, where different recombination velocities were produced on opposite surfaces by etching and mechanical polishing^{1, 8}. The Hall emf squeezes the lines of the control current alternately to differently-treated surfaces and thereby changes the overall conductivity of the plate by changing the average lifetime of the carriers¹⁰. The location of the plate 1 in waveguide 2, and also the relative orientation of the magnetic field H and of the current j , are shown in Figure 1. We used a high resistivity ($\rho \sim 35 - 40$ ohm-cm) n-type germanium, alloyed with antimony and having a free-carrier concentration $N \sim 10^{14}$ particles/cm³ and $\epsilon_1 \sim 16$. The plate thickness was $l = 0.25 - 1$ mm.

The normalized input impedance of the plate, the thickness of which is small compared with the length of the electromagnetic wave in the germanium, in a waveguide loaded by a matched load, has the following form¹¹:

$$Z_{BX} = 1 - \tan \delta \frac{2\pi l [\epsilon - (\lambda_0 / \lambda_{KP})^2]}{\lambda [1 - (\lambda_0 / \lambda_{KP})^2]} - j \frac{2\pi l [\epsilon - 1]}{\lambda [1 - (\lambda_0 / \lambda_{KP})^2]}$$

stant of high-resistivity semiconductors can be quite considerable, so that measurements of the dielectric constant of semiconductors can be performed at microwave frequencies to determine m^* and τ .

[†] This paper was delivered at the Third All-Union Conference of the Ministry of Higher Education U.S.S.R. on Radio Electronics, Kiev, 1959. It is reprinted from "News of the Higher Institutions of Learning, Radio Physics," Vol. 2, No. 6, 1959, pp. 911-914.

** In the Gaussian system of units.

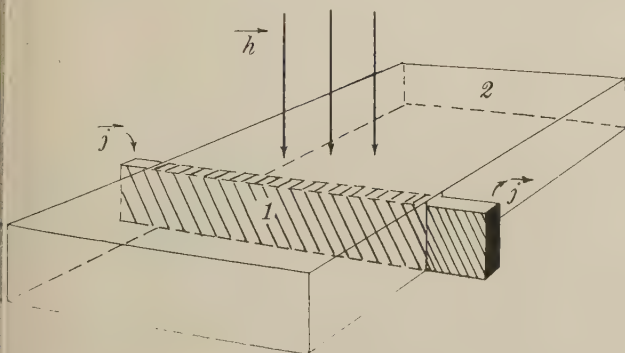


Figure 1

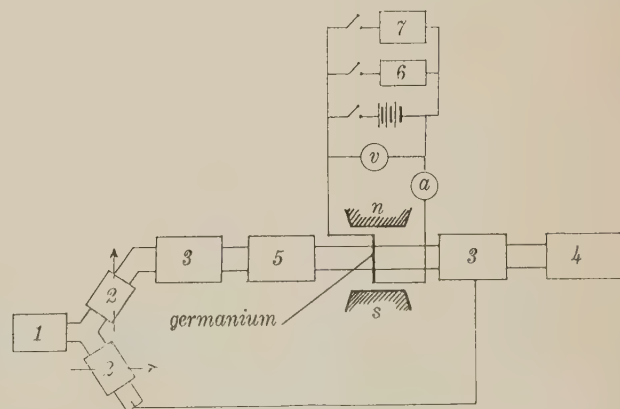


Figure 2 — Block diagram of the setup: 1 — generator, 2 — attenuators, 3 — measuring line, 4 — dummy antenna, 5 — measuring line, 6 — audio generator, 7 — pulse generator. Callout — germanium.

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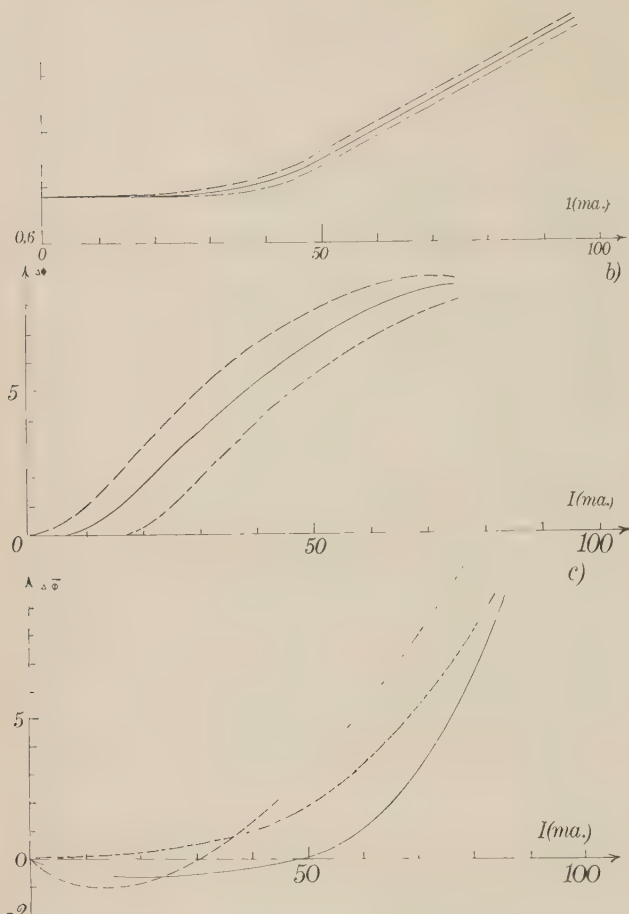


Figure 3 — Dependence of the modulus of the reflection coefficient, variation of the phase of the reflected wave ($\Delta\phi$) and of the transmitted wave ($\Delta\phi$) on the current I through the germanium plate. — no magnetic field, — — — in the presence of a magnetic field and different current direction — — — ($l = 0.95$ mm).

The modulus q and the phase ϕ of the reflection coefficient is given by the following expressions:

$$q \approx \frac{1}{\sqrt{1 + [\frac{2}{x'} - \tan \delta]^2}}$$

where

$$\phi = \arctan \frac{-2}{x' - 2 \tan \delta} \approx \arctan \frac{-\lambda [1 - (\lambda_0/\lambda_{KP})^2]^2}{\pi l (\epsilon - 1)}$$

where

$$x' = \frac{2\pi l [\epsilon - 1]}{\lambda [1 - (\lambda_0/\lambda_{KP})^2]}$$

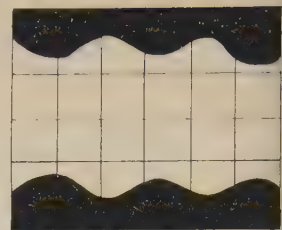
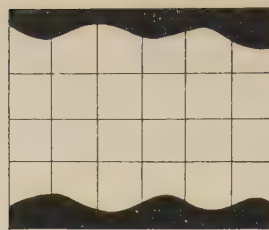
We see therefore that the modulus and phase of the reflection coefficient depends on ϵ . The corresponding dependence on ϵ and $\tan \delta$ holds also for the transmitted wave.

The experiment was carried out in the setup illustrated in Figure 2. The setup measured the phase and the modulus of the reflection coefficient, and also the phase of the transmitted wave as a function of the current flowing through the plate and of the intensity of the magnetic field.

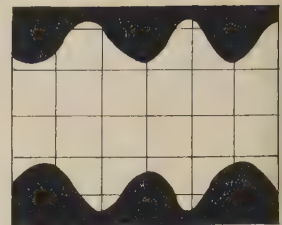
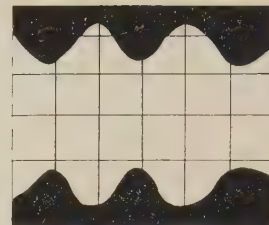
The results of the investigation can be summarized as follows:

The germanium plate in the magnetic field actually has different conductivity for currents in different directions

$H = 1,000$ oersted



$H = 3,000$ oersted



a)

b)

Figure 4 — Callout — $H = 1,000$ oersted, etc.

(a change in the current direction, for a fixed magnetic field, changes the conductivity by a factor of 2). Figure 3a illustrates the modulus (Figure 3a) and the phase (Figure 3b) of the coefficient of reflection, and also the variation of the phase of the transmitted wave (Figure 3c). Figure 3b and 3c illustrate the possibility of phase modulation the depth of which can be estimated from the difference in the values of the ordinates for the same value of the current (different current directions).

If the dummy antenna past the plate is replaced by a section with a piston located a quarter wavelength from the plate, it is possible to obtain a large phase modulation with small values of reflection coefficient.

With an alternating voltage applied to the plate, we investigated the modulation of the wave reflected from the germanium plate and the wave transmitted through it. The modulation was by means of an audio generator or a pulse generator. The dependence of the depth of modulation on the period of the modulating voltage was not observed up to pulses of duration 0.1 microsecond. Figure 4 shows oscillograms corresponding to modulation with a frequency of 500 cycles both in the reflected (Figure 4a) and the transmitted (Figure 4b) wave for values of magnetic field intensity of 1,000—3,000 oersted and a matched load.

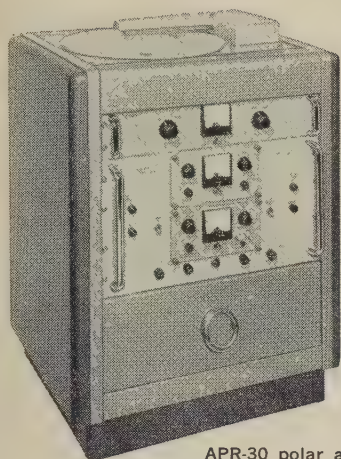
It must be noted that the increase in the difference between the recombination rates on both surfaces, due to better plate treatment, may considerably increase the efficiency of this modulator.

The authors express their gratitude to A. E. Nadzhip for help and consultation.

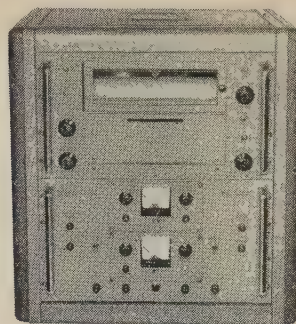
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Flexibility and Refinement



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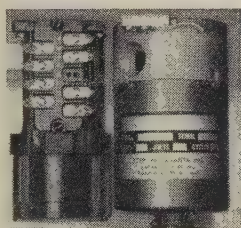
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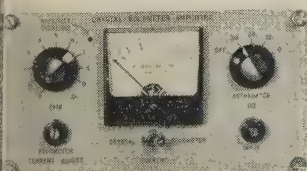
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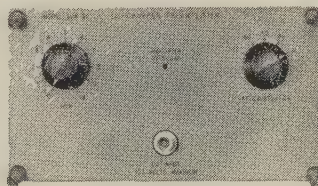
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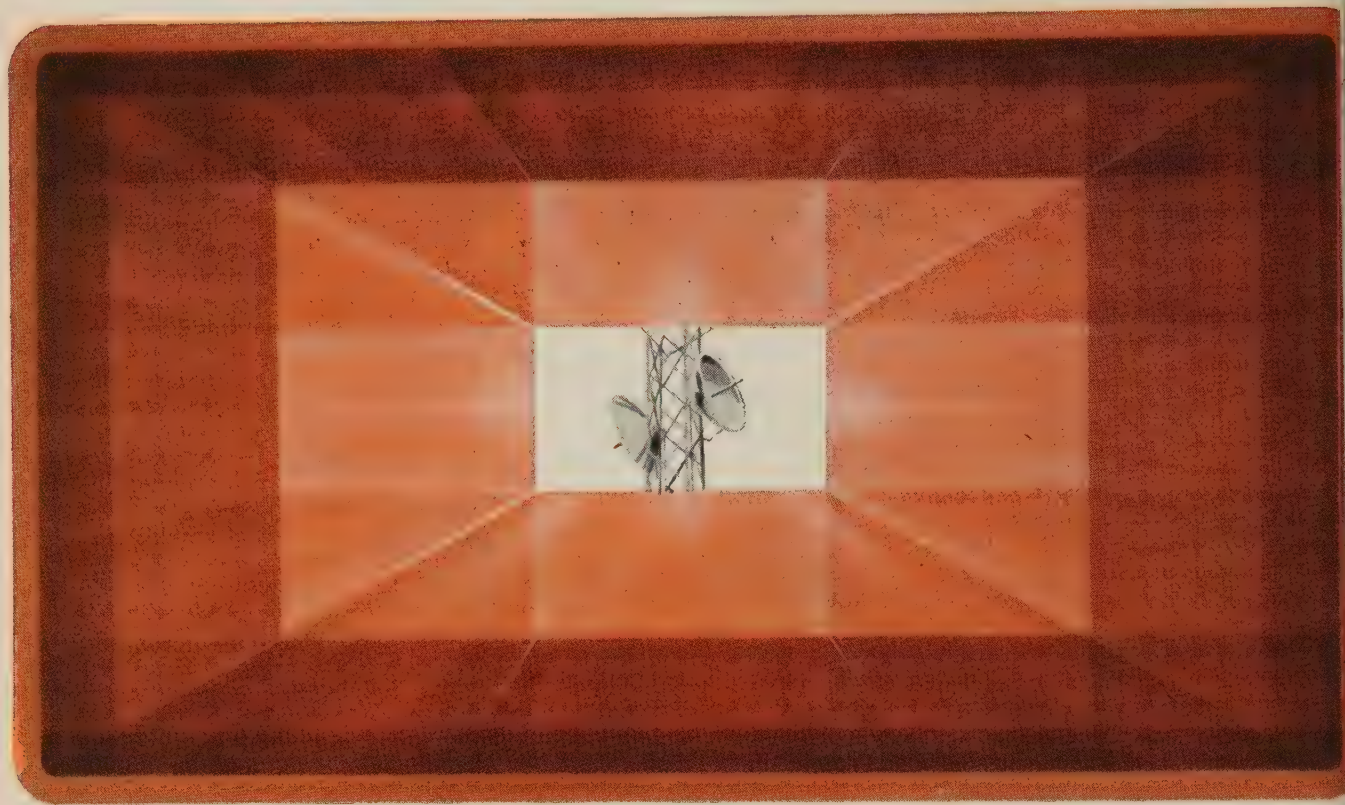
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cable military and commercial specifications and are available in the following family of sizes:

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RG-52/U · RG-91/U · RG-53/U · RG-110/U · RG-109/U

WR-229 · WR-159 · WR-75 · WR-51 · WR-34

Guides are fabricated in 12-foot mill lengths and in longer lengths on special order. Contact your Phelps Dodge representative for full information.

PHELPS DODGE COPPER PRODUCTS
CORPORATION

300 Park Avenue, New York 22, N. Y.



Circle Reader Service Card 54

(Continued from page 57)

AMPEREX ANNOUNCES HIGH POWER MICROWAVE TRIODE



Amperex Electronic Corp., Hicksville, Long Island, N. Y. announces type DX145A/EC157, a high gain, wide band, disc-seal microwave triode, which when operated as a narrow band CW amplifier will have a gain of 18 to 19 db with a power output of 0.5 watts at four kmc.

As a broadband amplifier at four kmc the DX145A/EC157 will have a gain of 12 db with a power output of 0.5 watts. Saturation CW power output can be as high as 2.5 watts. The DX145A/EC157 has an expected life of 10,000 hours and is guaranteed for 6,000 hours, which makes the tube ideal for unattended microwave stations.

While designed primarily for common carrier applications, the tube can also be expected to find widespread use in telemetry, industrial and test equipment applications. The tube can also be used as an oscillator, doubler, or tripler. As an oscillator, it will operate in the five kmc region, while as a doubler, it will provide a useful output at six kmc.

The DX145A/EC157 operates at 180 volts, which simplifies power supply, insulation and safety problems. It can be built into cavities for free air convection cooling at maximum power output. The tube is designed with a threaded grid ring which provides superior anode-cathode isolation and also simplifies tube replacement.

Circle Reader Service Card 109

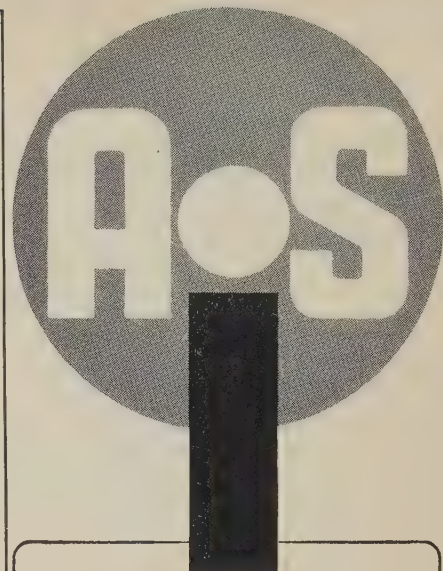
— m w j —

BOMAC INTRODUCES NEW COAXIAL LINE MONOPLEXERS

New Coaxial Line Monoplexers intended for use in radar systems utilizing separate transmitting and receiving antennas, are offered by Bomac Laboratories, Inc., Beverly, Mass.

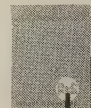
Typical monoplexers protect the receiver, both from the transmitted signal

(Continued on page 92)



Antenna Systems, Inc., is devoted exclusively to the design, fabrication and installation of antenna systems in the fields of scatter communications, missile tracking, space tracking, radar and surveillance, radio astronomy, and special antenna products.

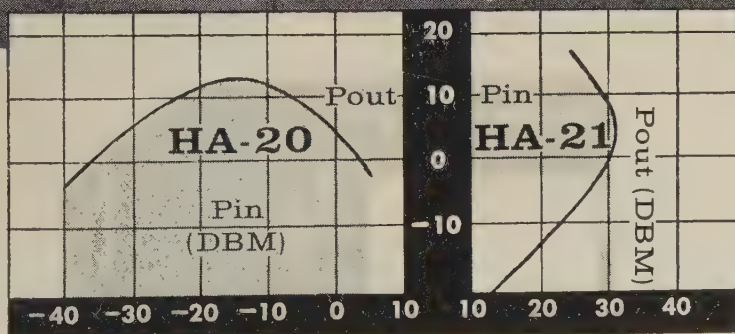
We invite your inquiry, whatever your antenna problem may be. Write for our folder.



ANTENNA SYSTEMS INC.
HINGHAM, MASS.

Circle Reader Service Card 50

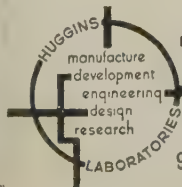
Cascade Operation of TWT's



Shown above are Huggins TWT's producing a power output range within ± 1 DB over an input range of -40 to +5 DBM.

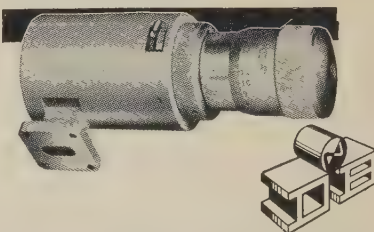
This pair of X-Band, light weight, PPM focused tubes is only one example of our ability to furnish TWT's to almost any specifications.

Please send for Engineering Note No. 6: "Cascading TWT's."



HUGGINS
LABORATORIES INC.
999 East Arques Avenue Sunnyvale, California REgent 6-9330

Circle Reader Service Card 53



BROAD BAND CAVITY WAVEMETERS

—gas filled for sustained accuracy

Accuracy is so high these instruments may be used as secondary standards. Units are unaffected by changes in humidity, altitude or barometric pressure. Only 12 sizes serve from 2.6 KMC to 140 KMC. You save budget money on the number of sizes needed. Literature on request.

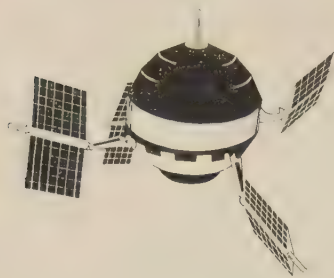


DE MORNAY-BONARDI
780 SOUTH ARROYO PARKWAY • PASADENA, CALIF.

Circle Reader Service Card 51

91

(Continued from page 91)



TRACKING DOWN A WHISPER AT 20,000,000 MILES

Keeping in touch with satellites in their solar orbits calls for detection of the last faint whisper of available signal strength. At ranges approaching 20,000,000 miles, the conservation of only 0.1 db in signal may add another 200,000 miles of closed contact.

At these extraterrestrial boundaries, optimum stabilization of parametric amplifier gain with antenna mismatches takes on critical importance, and utilization of the non-reciprocal properties of ferrite isolators to achieve this stability — without introducing excessive loss — appears indispensable.

For the Pioneer V, currently breaking all long-distance communications records, compact UHF isolators, developed by Motorola, provide this important assistance. At primary receiving stations in the satellite tracking network, these tiny ferrite devices help to improve receiver performance by stabilizing the gain of parametric amplifiers from changes in antenna impedance.

Motorola Type LI01 UHF Isolator, illustrated, provides more than 10 db isolation with less than 1 db insertion loss over a 30 mc bandwidth.

Originally designed for this satellite tracking application, Type LI01 is now a standard item ideally suited for all wide band, low power applications where minimum size and weight are essential without sacrifice to performance.



REPRESENTATIVE MOTOROLA SOLID STATE DEVICES

ISOLATORS • CIRCULATORS • PARAMETRIC
AMPLIFIERS • SWITCHING CIRCULATORS
• HIGH-SPEED, BROAD-BAND SWITCHES
• PHASE SHIFTERS •

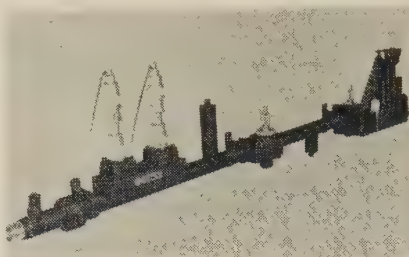
For detailed information write:

MOTOROLA INC.
Solid State Electronics
Department



8201 East McDowell Rd.,
Scottsdale, Arizona WHitney 5-6311

and from other signals accidentally directed at the receiving antenna. Terminated directional couplers are provided



for power monitoring purposes, along with two receiver protector tubes, and an output band pass filter.

The illustrated unit, designed for 7/8 inch coaxial line, is rated as follows: frequency, 406-450 mc . . . transmitter power peak, 30 kw . . . transmitter power ave., 50 watts.

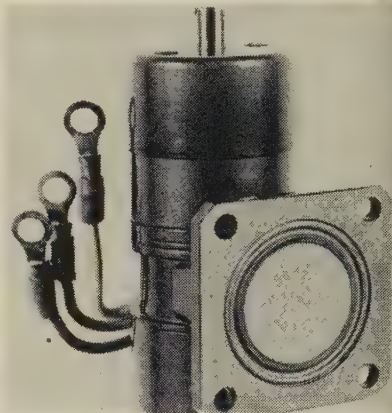
Circle Reader Service Card 110

— m w j —

TWO NEW MICROWAVE OSCILLATORS ANNOUNCED

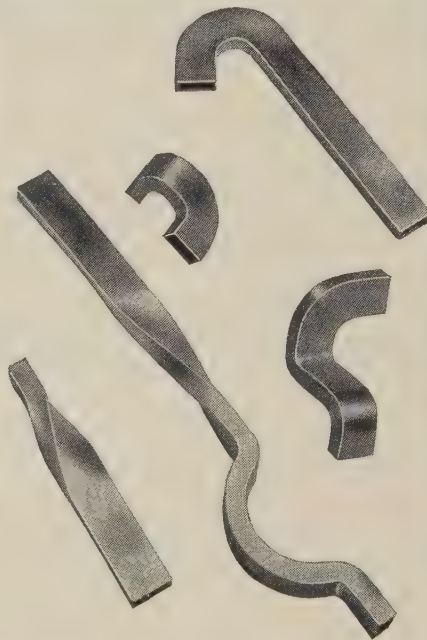
A new microwave reflex oscillator which completely eliminates the RF grids formerly found in such tubes has been announced by Sperry Electronic Tube Division, Sperry Rand Corp., Gainesville, Fla.

The major advantage of Sperry's new tube — a retarding field oscillator — is increased efficiency. At X band, efficiencies of three to four percent have been obtained in early studies. Sperry officials report that the RFO, in some cases, more than doubles the efficiency of conventional reflex klystrons. The tube's high efficiency greatly simplifies the power supply problems faced by system designers, and results in significant cost and weight reductions for systems.



In a conventional reflex oscillator, the only electrons useful in RF generation are those which successfully traverse through

(Continued on page 94)



**WAVEGUIDE
SPECIALISTS
IN CLOSE
TOLERANCE
BENDING
AND
FORMING**

**INTASPACE
CORP.**

135 ORANGE ST., BLOOMFIELD, N. J.
Pilgrim 8-4700

CONTROLLING TRANS ARABIAN'S PIPELINE VIA HIGH DIRECTIVITY VHF ARRAYS

Trans-Arabian Pipeline Company utilizes point-to-point multi-channel voice, teletype and mobile communications between its offices in Beirut, Lebanon and units along its pipeline from Saudi Arabia.

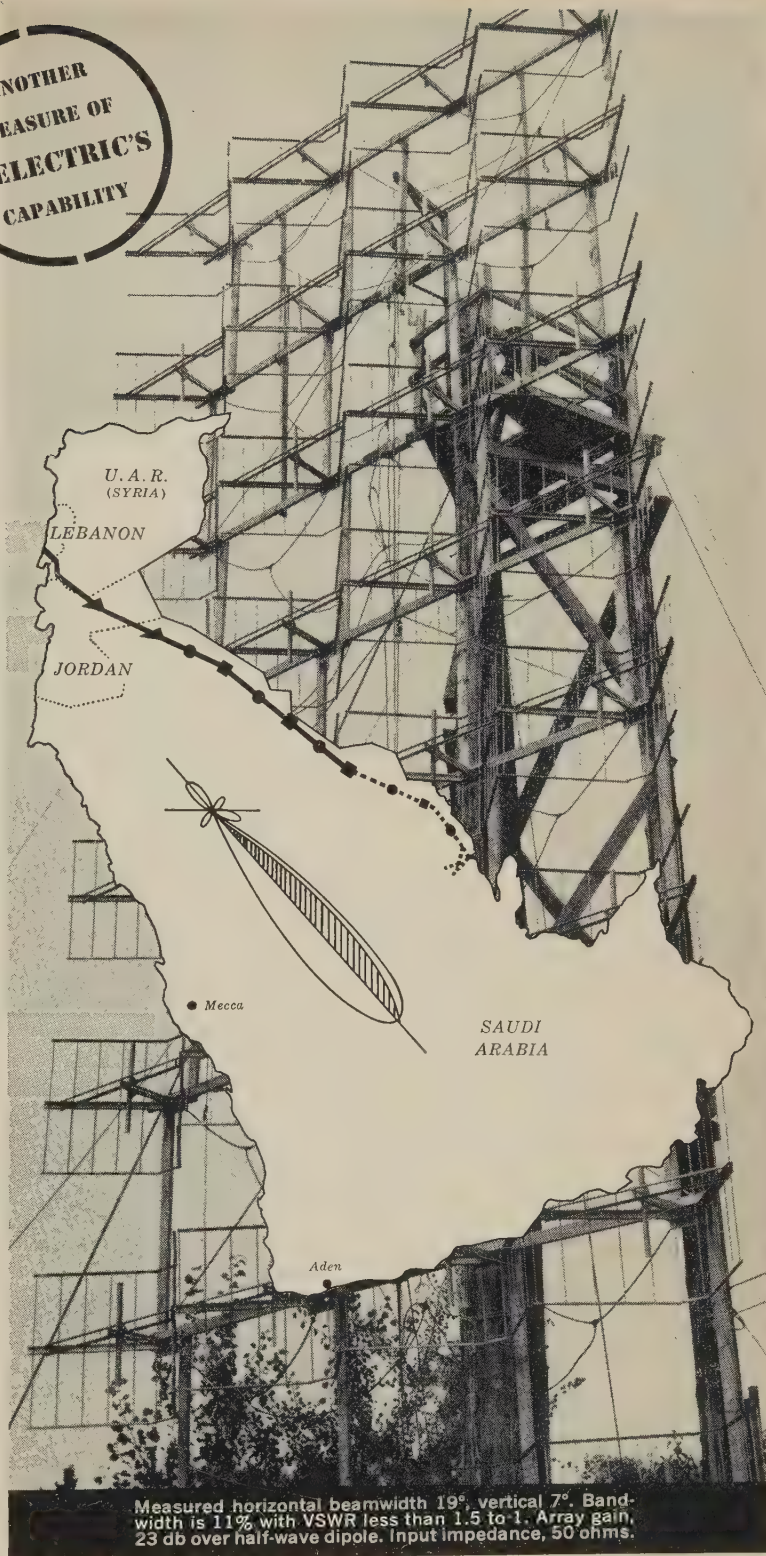
DIELECTRIC'S ASSIGNMENT: — to design and develop, for a substantial extension of this system, high directivity VHF antenna arrays for multi-channel communications and automated pipeline control.

To meet the requirement for an antenna system that would provide dependable, over-the-horizon communications at 160 mc . . . power, 250 watts . . . DIELECTRIC built five arrays (each with 32 corner reflectors), and complete with "corporate structure" feed system plus supporting and mounting hardware.

Also required was a network of coaxial band-pass filters for duplexing, tunable over the useful frequency range of the antenna. All of the elements had to be carefully adjusted at the factory and ready for installation at the site.

The design, development and complete testing of these arrays — plus disassembly, packaging and shipment to the site . . . ready for installation with minimum adjustments . . . in record time . . . is a significant measure of DIELECTRIC'S capability to solve difficult problems in communications, resourcefully and dependably.

If you'd like to put such high-level capability to work on your communications problems, talk to DIELECTRIC. Capabilities, facilities and accomplishments are described in our brochure. Write for it today.



Measured horizontal beamwidth 19°, vertical 7°. Bandwidth is 11% with VSWR less than 1.5 to 1. Array gain, 23 db over half-wave dipole. Input impedance, 50 ohms.

Other areas of DIELECTRIC capability in coaxial, waveguide and open wire techniques . . .

**TRANSMISSION LINE & COMPONENTS • NETWORKS • SWITCHES
TEST EQUIPMENT • R&D ENGINEERING**

consult **DIELECTRIC**
for solutions to
communications
problems.



DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE



NEW Miniature MICROWAVE OSCILLATOR CAVITIES now available

TRAK Electronics Company, Wilton, Connecticut, announces the formation of TRAK MICROWAVE CORPORATION to increase its developmental facilities for triode cavities in r-f signal generation from 500 Mc upwards. Present low, medium and high power cavities are available for application in grid pulse, plate pulse, and CW service.

TRAK expanded its Microwave Cavity line, which started in 1949, by adding the following 7 NEW miniature Cavities in 1960:

TRAK Type 9127-L	At 1090 Mc, tuneable ± 25 Mc, available from 900—1200 Mc.
TRAK Type 2958	At 925 Mc, tuneable ± 50 Mc, available from 500—2200 Mc.
TRAK Type 2959	At 1.5 KMc, tuneable ± 50 Mc, available from 500—2200 Mc.
TRAK Type 9127-SL	At 2 KMc, tuneable ± 100 Mc, available from 800—7000 Mc.
TRAK Type 9127-S	Available in 3 segments of S-Band: 2700—3000 Mc, 3000—3300 Mc, 3300—3600 Mc.
TRAK Type C-3136	Tuneable 2700—3400 Mc.
TRAK Type 9127-C	Tuneable 5400—5900 Mc.

ALSO, OSCILLATORS ENGINEERED to your specifications!

We invite you to write for new TRAK MICROWAVE CAVITY BULLETIN.



TRAK MICROWAVE CORPORATION
Subsidiary of
TRAK Electronics Company
5006 N. Coolidge Avenue
Tampa 3, Florida
Redwood 6-6422

apertures—the cavity entrance once and the cavity exit twice. Since these openings are gridded, current losses by interception are high.

In the RFO, electrons must pass through only one ungridded aperture. Losses are lowered, and a greater percentage of cathode current is available to deliver power to the load.

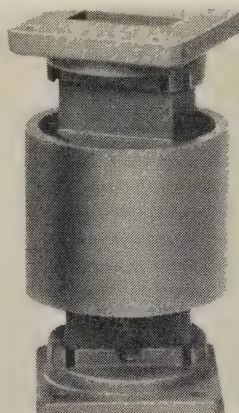
Other advantages of the gridless design include considerably increased ruggedness, lower spurious FM and thermal stability. Elimination of the grids also helps improve tube life, since the grids are a potential source of vacuum-polluting gases which could result in premature failure.

The present design, delivering one watt output at X band, was developed by Sperry in close cooperation with the Department of Electrical Engineering at Ohio State University. Future plans call for the development of retarding field oscillators in the C and K_u bands, as well as for increasing the efficiency of the X band model.

Circle Reader Service Card 111

—mwj—

TWO NEW WAVEGUIDE ROTARY JOINTS PRODUCED



Two new I-style waveguide rotary joints have been added to the family of stock-design rotary joints produced by Microwave Development Laboratories, Inc., Wellesley, Mass.

Operating in the 8.5 to 9.6 kmc range, the new I-joints are available in WR90 and WR112 EIA waveguide sizes. Each MDL rotary joint is fully tested before shipment, and is accompanied by a written certificate of electrical performance.

MDL I-style rotary joints may be ordered in either aluminum or copper alloy, in a variety of standard finishes. Both nonpressurized and 30-psig pressurized models are available.

Circle Reader Service Card 112

—mwj—

ALL-ELECTRONIC MILLI-MICROSECOND PULSE GENERATOR AVAILABLE



The first commercially available, all-electronic, millimicrosecond pulse source capable of delivering a positive and negative pulse simultaneously has been developed by Boston's Edgerton, Germann & Grier, Inc.

Shown for the first time at the National Electronics Conference in Chicago, the new instrument offers a number of other features including fast rise time: 0.1 millimicroseconds; a range of repetition rates from 10 to 100,000 pulses per second; single shot capability; and operability in any position due to the fact that no mercury switches are employed.

Pulse amplitudes are fixed at approximately eight volts into 50 ohms. Pulse width may be varied from two to 100 millimicroseconds by means of an external charge cable and outputs are preceded by a trigger pulse available on the front panel. Time difference between trigger pulse and main pulses is selectable over a 100 millimicrosecond range and vernier adjustments are provided for main pulse timing.

Model 750 can be triggered from an external source delivering a positive pulse. The unit operates on standard AC. Size is approximately 10 inches x 10 inches x 13 inches and weight is 15 lbs.

Circle Reader Service Card 113

—mwj—

SWITCH FOR PRESSURIZED RADAR-DOMES CONSTRUCTED

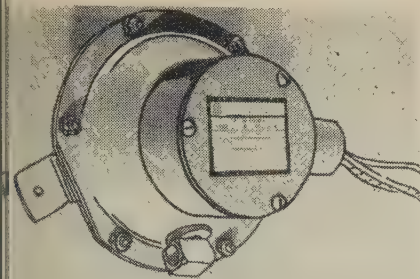
The Cat. 130D8HA5P Switch, specifically constructed as a controller for regulating air pressure in inflated plastic radar-domes, has been announced by Dietz Co., Inc., Long Island City, N. Y.

The Switch may be located in or out of plastic radar-dome housing since it is manufactured as a differential pressure switch.

The Cat. 130D8HA5P Switch is responsive to pressure as low as 0.25 inch water column with on-off switch differential of 0.1 inch water column when switch is supplied with a range of eight inches water column. The pressure setting are readily adjustable by means of an

the microwave journal

adjusting screw in the field. A maximum pressure of 40 inches water column can be applied to switch without damage.



Switch housing is dust-tight and splash-proof with Cannon plug connector for electrical connections. The electrical ratings of the single pole, double throw contacts are 15 amperes at 120-250 volts A. C., 1/8 H. P. or 125 volts amperes pilot duty.

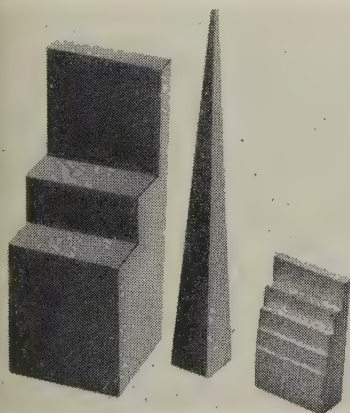
Suited for Military applications where a sensitive low pressure switch is desired with reliability and ruggedness in small size, the Switch is manufactured to Military specifications for ground support equipment. The Unit is five inches in diameter with a depth of four inches and weighs 1½ pounds.

Circle Reader Service Card 114

— m w j —

NEW HIGH TEMPERATURE PERMEABLE DIELECTRIC AVAILABLE

A new microwave absorber capable of operation at temperatures up to 800° C with no detectable change in electrical or physical characteristics is now available from Custom Components, Inc., Caldwell, New Jersey.



The new permeable dielectric, CMA 701, has a dielectric constant of 50 at 20 Mc, and an attenuation of more than 38 db/cm at 8.2 kmc, and of more than 26 db/cm at 10 kmc. It has a density of 4.05. The material can be machined or molded into shapes suitable for waveguide termination.

In addition to immediately available shapes, the factory will provide custom shapes of CMA 701 on 30 days' notice.

Circle Reader Service Card 115

— m w j —

PRECISION ATTENUATOR SET FOR STANDARDS LABORATORIES

Weinschel Engineering, Kensington, Md., has announced the Model AS-1 Precision Attenuator Set consisting of eight precision coaxial attenuators in a solid walnut, velvet-lined case with a stainless-steel nameplate.

Attenuators included are: Weinschel Model 210 (Frequency Range 1-12.4 kmc) in values of 3, 6, 10, and 20 db; Weinschel Model 50 (Frequency Range DC to 1 kmc) in values of 3, 6, 10, and 20 db.

All eight attenuators have stainless steel bodies and connectors (Type N, male/female) for long life and are made with Weinschel Film Resistors for maximum stability.

Mounted in the lid of each case is a plastic-laminated Certificate of Calibration giving the data on each individual at-



tenuator: Model 210 has DC resistance and Insertion loss at 1, 2, 4, and 10 kmc, and Model 50 has DC resistance and Insertion loss (to an accuracy of .02 db at 3, 6, and 10 db and .04 db at 20 db) at DC, .4 kmc and 1.0 kmc.

Each certificate is signed by the Chief Engineer of Weinschel Engineering. Simple DC measurements will serve to ascertain long term stability.

Circle Reader Service Card 116

— m w j —

TI EXTENDS RANGE OF MICROWAVE VARACTOR DIODES

Texas Instruments, Inc., Dallas, Tex., announced recently that it has established a new ceiling on the high-frequency capabilities of diodes by adding three new device types—the XD-501, -502, and -503—to its line of diffused gallium arsenide mesa microwave varactor diodes. The new XD-503 is rated for a Minimum Cutoff Frequency at Breakdown of 310 kmc.

At $V_R = -2v$, the minimum cutoff frequencies of the XD-500, -501, -502, and -503 are rated at 60, 81, 108, and 144 kmc, respectively. These microwave varactors are packaged in the TI-developed double-ended beryllium oxide cartridge, developed specifically for optimum microwave performance. Designers of microwave equipment can now specify the cutoff frequency range best suited to their particular applications.

(Continued on page 96)

WEINSCHTEL

FIXED COAXIAL ATTENUATORS

Models 50, 51, 52

DC to 1 KMC, Usable to 2 KMC

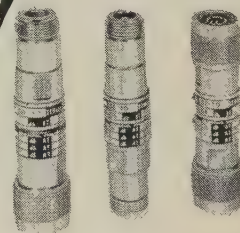
Attenuation: 1 to 50 db

High stability, low frequency sensitivity

Finish: Stainless Steel (Type N Connectors);

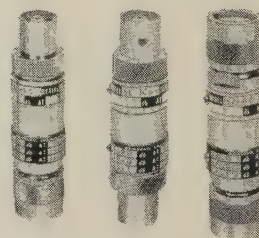
Nickel Plated (Type C or SC Connectors)

Type N Connectors



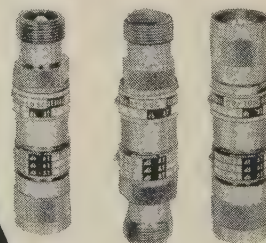
1 male 2 female 2 male
1 female

Type C Connectors



1 male 2 female 2 male
1 female

Type SC Connectors



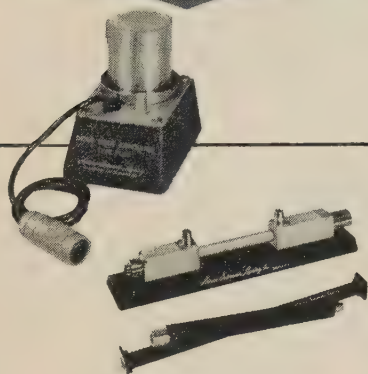
1 male 2 female 2 male
1 female

Complete specifications upon request. Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog.

Weinschel Engineering
KENSINGTON, MARYLAND

Circle Reader Service Card 56

Noise Generators for All Frequencies from 10 mc to 40 kmc



The AIL Type 70 series of Noise Generators provide the most complete frequency coverage available. Argon gas discharge tubes are used resulting in stable operation and a secondary standard of relative excess noise temperature. All models may be powered by the Type 74 Automatic Noise Figure Indicator or, the the Type 71 Power Supply.

- 8 Waveguide Units:
2.6-40 kmc
- 1 Coaxial Unit:
0.2-2.6 kmc
- 2 Diode Units:
10-300 mc
- Relative Excess Noise
Temperature: 15.28 db
- Accuracy:
 ± 0.25 db; 50 ohm output

Write for complete description.



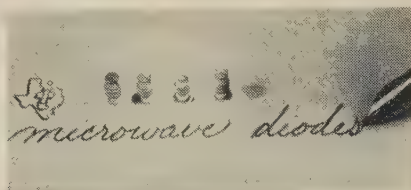
**AIRBORNE
INSTRUMENTS
LABORATORY**

DEER PARK, LONG ISLAND, NEW YORK
A DIVISION
OF CUTLER-HAMMER, INC.

New Products

(Continued from page 95)

The new TI microwave mesa varactors also feature low total capacitance range ($0.5 \mu\text{mf}$ min to $1.4 \mu\text{mf}$ max) and low



series inductance ($0.7 \text{ m}\mu\text{h}$ at 9.4 kmc). The low noise levels and high frequency capabilities thus produced in the TI XD-500 Series Microwave Varactor Diodes reduce the size and weight and improve the performance of parametric amplifiers, communications networks, missile/space vehicles, radar sets, telemetry systems, and other microwave equipment.

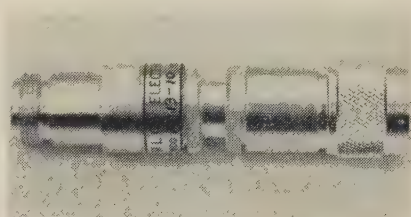
Circle Reader Service Card 117

— m w j —

RLC ANNOUNCES NEW FIXED ATTENUATOR MODEL

A new line of precision coaxial attenuators designed for operation from DC to 10 kmc has been announced by RLC Electronics, Inc., Mamaroneck, N. Y.

These fixed attenuator pads, Model A-13, can be supplied in attenuation values from 0 to 60 db. The attenuator accuracy up to 30 db (including absolute accuracy and variation of attenuation as a function of frequency) is $\frac{1}{2}$ db; the accuracy of pads from 30 db to 60 db is $\frac{3}{4}$ db. VSWR of these units with Type N connectors is 1.3 maximum from DC to 10 kmc. Power rating is one watt. These units are calibrated at 2.8 kmc and 9.5 kmc and can be supplied with Type



N, C and TNC connectors. They are designed for 50 ohms and are fabricated from silver plated brass.

Model A-13 is but one of a comprehensive line of coaxial attenuators ranging in power rating up to 50 watts. Special attenuators requiring extremely close tolerances, differences in frequency range, higher power levels, special connectors, different materials and finishes, etc. can also be supplied. RLC also produces a wide range of terminations and filters. Complete information about Model A-13 attenuator and other items in its line can be secured on request.

Circle Reader Service Card 118

— m w j —

GALLIUM ARSENIDE MIXER DIODE INTRODUCED

Philco Corp.'s Lansdale, Pa. Division has introduced a commercially available gallium arsenide microwave mixer diode — the IN3096R.

The new device is specified for 24,000 mc (K-band) first detector operation and is housed in a coaxial package identical to that used for existing silicon K-band diodes.

According to Charles S. McCarthy, Jr., sales manager — microwave, the IN3096R features a band-gap energy value of 1.40 eV electron volts and is capable of high temperature operation considerably in excess of the upper limit capabilities of germanium and silicon components. Higher mobility values achieved by the IN3096R permit greatly increased sensitivity at 24 kmc.



The gallium arsenide diode exhibits an overall noise figure of 10.5 db, surpassing the lowest noise figure available for any K-band crystal.

Design quantities (1-9) of the IN3096R are immediately available at a unit price of \$75.00. Matched pairs, designated IN3096RM, are also available at a per pair price of \$187.50 within three weeks of notice.

Circle Reader Service Card 119

— m w j —

ELECTRONICALLY-TUNED MICROWAVE FILTER ANNOUNCED

Watkins-Johnson Co., Palo Alto, Cal., has announced the commercial availability of its WJ-501, an electronically-tuned microwave filter. It is a microwave pre-selector filter which can be electronically tuned over a wide range of frequencies with low insertion noise. The device uses the principle of low-loss gyromagnetic resonance in single crystal yttrium iron garnet (YIG) to achieve a high-Q resonant structure whose resonant frequency can be changed by means of a dc magnetic field.

The WJ-501 covers the full 2-4 kmc band, with a three db bandwidth of approximately 25 mc showing insertion

(Continued on page 99)

the microwave journal

POLARAD

PROVEN RELIABILITY

ABSOLUTE POWER LEVEL

NEW CALIBRATED FIELD INTENSITY RECEIVER 1,000 to 10,000 mc*

Indicates Absolute Power Level By
Comparing Input Signal Against
Internally Generated Signal
In A Single Unit

- Only Field Intensity Meter approved Category A MIL-I-26600 at these frequencies.
- Model FIM accurately measures frequency and absolute power level of microwave energy.
- Only microwave Field Intensity Receiver with self-contained signal generator which calibrates entire system under test at any level.
- First single microwave test system to determine radiated r-f interference and susceptibility.
- Front-panel meter indicates average, peak, slide-back peak or quasi-peak value of r-f signals. Outputs for video, audio and recorder.
- Four interchangeable tuning heads cover 1,000 to 10,000 mc.*
- Direct-indicating peak VTVM for ease of frequency location of impulse noise.
- Single UNI-DIAL tuning control tunes both the receiver and signal generator.
- Calibrated antenna system includes an omni-directional broad band antenna and a separate directional antenna to match each tuning unit.

*Two compatible tuning units under development will extend frequency to 20,000 mc.

**FREE LIFETIME
SERVICE**

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes On Microwave Measurements."

POLARAD
ELECTRONICS CORPORATION
43-20 34th St., Long Island City 1, N. Y.



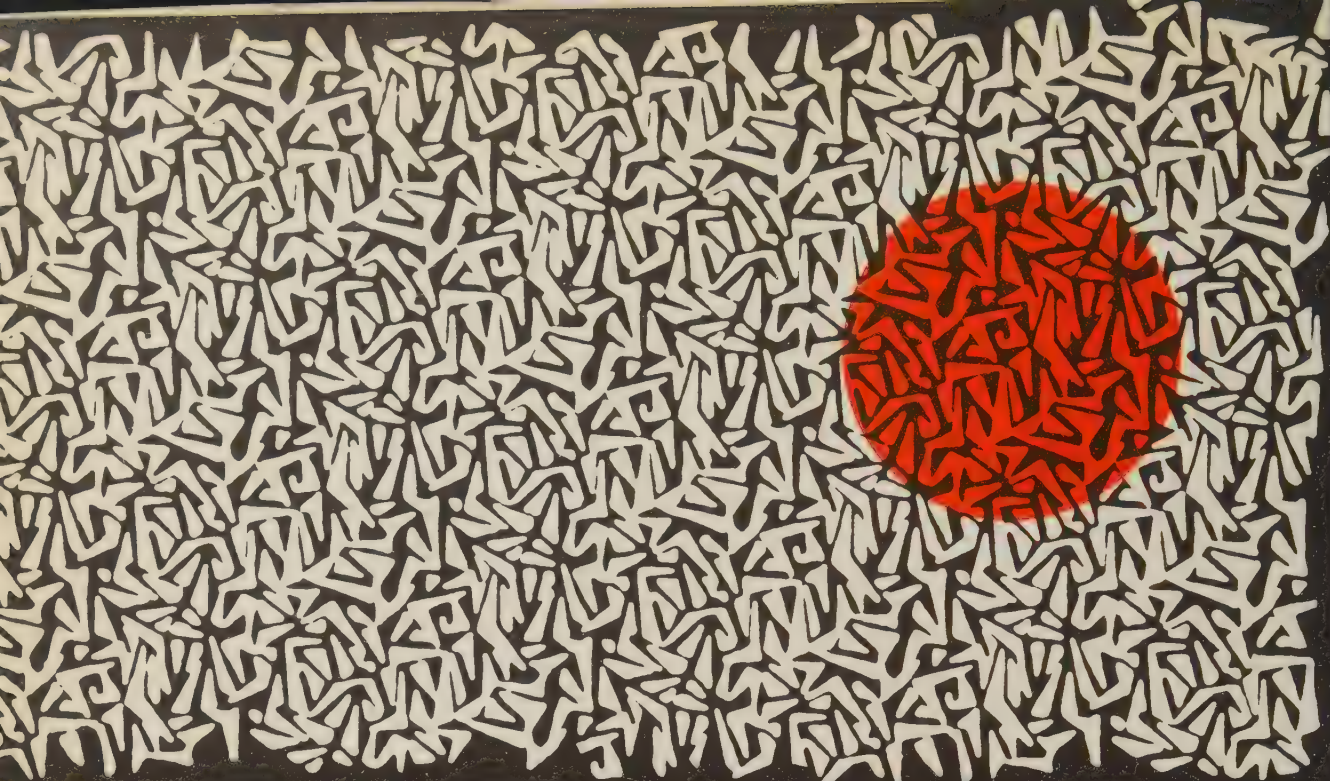
Model FIM

POLARAD ELECTRONICS CORPORATION:

Please send me information and specifications on:

- ☐ Model FIM Calibrated Microwave Field Intensity Receiver
My application is _____
- ☐ Model MSG-1 and MSG-2A Signal Generators
My application is _____
(See reverse side)

Name			
Title	Department		
Company			
Address			
City	Zone	State	



Model MSG-2A

MAIL THIS CARD FOR SPECIFICATIONS

Postage
Will be Paid
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Addressee

No
Postage Stamp
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if Mailed in the
United States

BUSINESS REPLY CARD

First Class Permit No. 18, Long Island City, N.Y.

POLARAD ELECTRONICS CORP.
43-20 34th St., Long Island City 1, N. Y.



MICROWAVE SIGNAL GENERATORS

950 to 4,600 mc

PROVEN DESIGNS Generate Signals of
Calibrated Frequency and Power Output Level.

- Provide internal pulse, square wave, FM and CW outputs.
- Versatile single or multi-pulse external modulation.
- Continuously adjustable pulse repetition frequency, pulse width and pulse delay.
- Frequency accuracy: ± 1 percent.
- Power output: 1 milliwatt (0 dbm)

MODEL	FREQUENCY
MSG-1	950 to 2,400 mc
MSG-2A	2,000 to 4,600 mc

POLARAD
ELECTRONICS CORPORATION

FREE LIFETIME
SERVICE

43-20 34th Street,
Long Island City 1, N. Y.

New Products

(Continued from page 96)

losses ranging from three db at two kmc to one db at four kmc. If higher selectivities are required, multiple-tuned structures can be designed at the expense of in-



creased insertion loss at resonance. Band-rejection filters of similar characteristics have been built. Band-pass and band-rejection filters can be built at frequencies through 30 kmc for specific applications. The complete WJ-501 (15 cubic inches, 1-1/2 pounds) is priced at \$870 for four-weeks delivery.

Circle Reader Service Card 120

—mwj—

HYCON DEVELOPS X-BAND STRIP LINE CIRCULATOR

A three ounce X-band circulator has been developed by the Hycon Mfg. Co., Pasadena, Cal. The new strip line circulator is the first of a series of miniaturized components for microwave systems developed by the Microwave Research Group at Hycon.

The tiny Hycon X-band circulator has minimum isolation of 20 db and a maximum insertion loss of 0.4 db over a 6 per cent band. The package is less than 1/4 inch high and 1 1/2 inches in diameter less TNC coax connectors. The new unit has a VSWR of less than 1.4:1, handles 10 watts average power and 100-watts peak power. Input impedance is 50 ohms.



The new Hycon circulator can be designed into a composite strip line circuit thus eliminating connectors between elements. Limited quantities of the tiny X-band circulators are available on 30 day notice.

Circle Reader Service Card 121

—mwj—



EXCELLENT form-factor and operating versatility make these rugged magnetrons ideal for many small-package applications including CW or pulsed radar beacons, test equipment oscillators, airborne navigation, proximity detection, surveillance, and transponder type operations.

Light, dependable, and with proven capabilities, these tubes operate at 500 to 600 peak volts and 150 ma peak pulsed current, permitting low-cost modulator components for all applications. They give a nominal power output of 1 watt CW and 15 watts peak.

Engineering programs in progress at Microwave Associates are directed towards development of this tube as a voltage-tunable magnetron within the same form-factor. Your inquiries are welcomed on these and other magnetrons.

A copy of our new 72 page Magnetron Catalog is available upon written request on your company letterhead.



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C992100-405	2.0—2.5 KMC	30 DB Min.	.8 DB Max.	1.20
C992100-404	2.0—4.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-407	3.0—3.5 KMC	35 DB Min.	.8 DB Max.	1.20
C993100-401	4.0—8.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C994100-403	7.0—9.0 KMC	25 DB Min.	.8 DB Max.	1.20

Complete information on these or all of the models is available by directing inquiries to: 14844 Oxnard Street, Van Nuys, California, or the sales office in your area.



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Letter to the Editor

the microwave journal
Brookline 46, Massachusetts

Dear Sirs:

This is to call your attention to what I believe is a misprint in a formula in the article by Hensperger, "The Design of Multi-hole Coupling Arrays", which appeared in the *journal* for August, 1959. In Figure 1, Page 38 the formula for C (DB) should have the factor +6.0 DB at the end instead of -6.0 DB.

The 6 DB factor represents, according to the author, the difference between a two-hole and a one-hole coupler. Thus, since the coupling is expressed as a positive number, in DB down, the value of coupling in DB becomes larger when the power coupled is smaller, making it +6DB rather than -6DB.

Very truly yours,
Alan J. Simmons
Technical Research Group
Somerville 43, Mass.

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the microwave journal

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INDIANA GENERAL CORPORATION

*Valparaiso,
Indiana*

When the nucleus of Indiana General Corporation first appeared, few could have predicted that the company today would be contributing to the harnessing of microwave channels. Marconi and DeForest had done their pioneering work, but probably not even they had envisioned the ramifications of their discoveries. Nor would the potentialities of two widely separated plants which are now the heart of Indiana General Corp. have been predicted.

In 1908, a blacksmith shop in the rolling Indiana countryside began forging steel magnets. Two years earlier and nearly 1,000 miles away, a group of German ceramists undertook the production of huge earthenware vessels for the branches of the chemical industry which their countrymen had recently established in the United States.

The first enterprise became The Indiana Steel Products Company, of Valparaiso, Indiana; the second, General Ceramics Corporation, of Keasbey, New Jersey. Last year, General Ceramics was merged into Indiana Steel Products and the surviving corporation, Indiana Steel, was renamed Indiana General Corporation. Sales for 1959 totaled nearly \$20 million, with prospects good for a satisfactory increase this year.

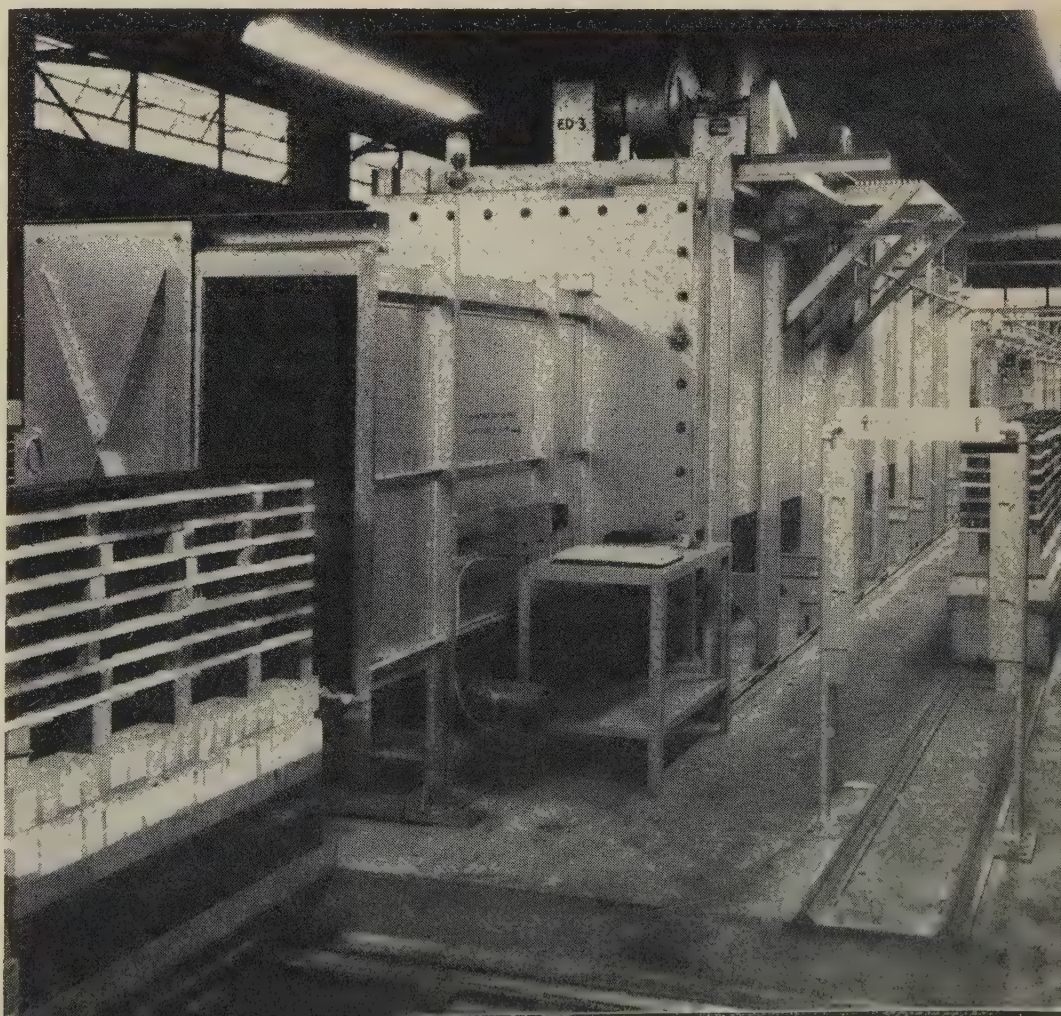
Thus was born a major element of that branch of the electronics industry engaged in the development, manufacture, and marketing of permanent magnets, ferrite magnetic materials, and various equipment utilizing both. One of the most exciting markets for these products is the microwave industry.

Although the company's early history may at first glance seem unrelated, it provides a solid background of experience of substantial value to the microwave field.

Indiana Steel Products Division

When The Indiana Steel Products Company opened for business, a handful of alloys, consisting of high carbon steel, chrome, and tungsten steel, were fashioned into the then limited bar and horseshoe shaped magnets. The

The new kiln at General Ceramics Division in Keasbey, New Jersey is the largest kiln for the production of ferrites in the country. Temperatures in the kiln are carefully controlled throughout its length. Similar equipment is in daily use at Indiana Steel Products Indox magnet plant.





Workman die-casts aluminum covers for Alnico permanent radar magnets at the Indiana Steel Products Division in Valparaiso, Indiana. Covers are shown in the right foreground and aluminum bar stock at left.

year 1935 saw the development of a radical innovation, the Alnico magnet. The Indiana Steel Products Company was soon making them, and its research chief, the late Charles A. Maynard, was soon improving upon the first formulations. Nearly two decades later, barium ferrite permanent magnets, made by a ceramic manufacturing process, were introduced by ISP to the American market. Indiana Steel named them Indox, which has become a synonym for barium ferrite. In 1959 it built a new plant exclusively for the production of these ceramic magnets.

The Indiana Steel Products Division was a pioneer in the microwave field. Because of its long experience in the development and production of magnets, it was chosen to be one of the first companies during World War II to make the magnets used in magnetron tubes. Tons of these magnets were produced, and went to work against the enemy in every theatre.

The first magnetron components turned out by Indiana were made of Alnico V. This turned out to be a definite improvement over materials used in the experimental radar units of the immediate pre-war period—and were also less expensive. Indiana Steel originated the C-shaped magnetron horn; and later developed the E-shaped assembly, which was considered the ultimate during that period. Mr. Charles A. Maynard, Indiana's vice president-engineering, contributed greatly to the company's success

during these war years. He was responsible for supplying the most efficient design for the magnetron units, which required less amounts of critical materials, such as nickel and cobalt. For its work on magnetrons during the war the company was presented the Army-Navy Production Award.

Today Alnico V is still the most satisfactory material for most magnetron applications because of the high flux density required with the least amount of volume.

General Ceramics Division

Although its steatites were used to insulate the bases of radar installations during the war, the General Ceramics Division of Indiana General Corp. did not become centrally involved in microwave products until later. In this sense, however, the story also goes back to World War II. During the war, Dr. Ernst Albers-Schoenberg, the distinguished German scientist and ceramist, did some preliminary experimental work on ferrites, but the Allied bombings of Berlin, where he worked, forced him to discontinue his activities.

After the war, he worked in the Soviet zone of Berlin but lived in the French zone. Several times the Russians asked him to move to Moscow and carry on his research there. He declined. When these invitations became insistent, he quit his position with a ceramics firm and avoided the Soviet zone. The Arnhold family, which then owned General Ceramics, brought him to this country. The day he arrived, he urged the Arnholds to move into the ferrite field, which was at the time of no commercial importance. This was a far cry from the chemical processing equipment, steatites, and other ceramic products which the company had made. But Dr. Albers-Schoenberg was established in a small laboratory in the General Ceramics plant in Keasbey, New Jersey; he immediately began to investigate the properties of ferrites.

The first ferrite marketed by General Ceramics (in 1949) was Ferramic A, which was snapped up in as great quantities as the company could produce by the television industry. Ferramic A cores were used in flyback transformers.

This material gave promise of being useful for its Faraday rotational effect. Several researchers experimented with it. A few years later Bell Telephone Laboratories scientists described to Dr. Albers-Schoenberg the characteristics needed in wave guides and about the same time, the Naval Research Laboratories tried standard ferrites, such as Ferramic D, in wave guides and published the results. It was becoming clear that ferrites were potentially important in waveguides.

In 1952, working under a development contract with Raytheon Manufacturing Company, Dr. Albers-Schoenberg produced an experimental body known as MS-1331, which was designed specifically for its rotational characteristics. Out of MS-1331 grew the first commercially available microwave ferrite, which General Ceramics called R-1. It was specifically for X-band applications, and was offered initially in 1953.

After R-1 proved itself, the microwave industry began calling for ferrites for other frequencies. In 1956 Sperry entered into a development contract with General Ceramics, which resulted in the R-4, for X-band and, in some applications, for S-band work. Two years later R-5 (for

C-band) and R-6 (for S-band and below) were added to General Ceramic's list of microwave materials. All are available as standard materials. In addition General Ceramics grinds the stock to customers' specifications, a tricky operation because of the hardness of the material.

Meanwhile, the Indiana Steel Products Division was not resting on its wartime laurels. Indox and Alnico materials were being developed. For example, Indox VI, which has the highest coercive force of any commercially available material of its kind, was developed in 1959. Manufactured in the company's new ceramic magnet plant in the outskirts of Valparaiso, it was designed specifically for the microwave industry. Indox VI, as well as Indox I, are particularly well suited for periodic focusing of traveling wave tubes. Indox V, the first oriented ceramic magnet, was ushered into the magnetics industry in 1956.

Another new material from IGC laboratories is Alnico 7-7, which has the highest energy product of any permanent magnet material. It is well suited to airborne and other applications where a small, light, but potent magnet is required. Indiana scientists are now at work developing other permanent magnet materials for microwave applications.

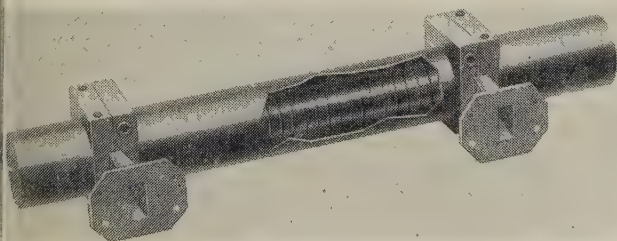
Indiana General Corporation

What sort of company does it take to develop and produce specialized materials such as these?

Only a scientifically-oriented concern, which IGC has long been, could do the job. This orientation is one in which management, scientists, and engineers take great satisfaction.

Because of this emphasis, Indiana has found it possible to recruit able, imaginative, highly qualified specialists to maintain its high standards. That the company can hold such men in the face of attractive offers from larger organizations in the electronics field suggests that management has found a formula for keeping its skilled personnel content.

Robert F. Smith, president and chief executive officer, and John H. Bouwmeester, executive vice-president, have surrounded themselves with engineers who "know their stuff." They have looked for young men, at the threshold of their career, who have many years in which to develop and to make their contribution to the technology of magnetism. An atmosphere of flexibility makes it possible for a man to work in the research laboratories one month and with the production crews the next. This variety of activity makes life more interesting for the engineer. And it brings fresh ideas and approaches to bear on problems facing the company. "Cross fertilization," Smith and Bouwmeester call it.



Indox VI permanent magnets, like those shown in this typical traveling wave tube, were designed especially for this application by Indiana Steel Products Division.



Because of the demands for materials which withstand the heat of atmospheric friction and the cold of outer space, the behavior of magnetic materials at extremes of temperature has assumed a new importance. Here an Indiana scientist checks a magnet in a cold chamber.

Research and Development

Few materials manufacturers—that is basically what Indiana is—devote so much time, effort, and money to R&D. Indiana General Corporation invests—the verb is used advisedly—some 5 per cent of sales in R&D—an unusually high proportion for a company of its size.

In Valparaiso, the visitor may see the Air Force Laboratory, in which basic investigations of the metallurgical structure of magnetic materials, studies of the effect of temperature on the phenomenon of magnetism, and inquiries into the stability of permanent magnets are going forward.

In Keasbey, the visitor will find literally thousands of tiny vials, each containing a different ferrite formulation. At any time, one can see a battery of technicians measuring the characteristics of new bodies. Of the Keasbey Laboratory it has been said, "There are more scopes per cubic engineer here than in any comparable concern." The volume and variety of equipment is impressive.

Comments President Smith: "I don't ask my secretary to carry on without a typewriter and I don't ask my engineers to do their work without the necessary tools."

Amplifying his philosophy, he continued: "We don't put our research team off in a corner of the plant, nor do we set them up in an aluminum-and-glass lab beside a lovely lake out in the country. Our R&D people are central to our operation and we keep them in the swim instead of isolating them. We want them to rub elbows with our sales engineers, our production supervisors, with management, and especially with customers.

"Above all, we talk to the customer, find out his prob-

lems, and try to help him resolve those problems. We'll send a research scientist out to the customer's plant to render assistance if he can. In the retail trade they say that the customer is always right. Maybe he is and maybe he isn't, but he certainly knows what his problems are. By working closely with the customer we help him and we help ourselves. This is, incidentally, one of the best ways to study our markets.

"Because of our flexibility, we can assign a dozen men to a crash program if necessary, and, for a company of our size, that is quite a force. We can shift quickly from one project to another without a lot of red tape."

Executive vice-president Bouwmeester summed it up another way: "We're a shirt-sleeve outfit," he said.

At Indiana, the highest emphasis is placed upon quality. Since the company makes soft, hard, and square loop as well as rotational magnetic materials—each group calling for quite different ingredients, producing different and sometimes opposite characteristics—great care to avoid contamination must be taken.

A certain standard in physical size and financial resources must be met in order to serve an industry as complex and fast-moving as the microwave field.

In addition to its two plants in Valparaiso and the installation in Keasbey, Indiana has the Stearns Magnetic Products Division in Milwaukee, Wis., and a wholly-owned subsidiary in Kitchener, Ont., the Indiana Steel Products Company of Canada, Ltd. Stearns develops and manufactures magnetic separation and materials handling equipment for a wide cross-section of industry. The Canadian concern makes permanent magnets, stainless steel castings, and one type of magnetic separator. Recently it became the first firm in Canada to stock ferrites as shelf items.

Indiana General Corporation has some 1,400 employees, many with the company for 20 and 30 years. It has more than 500,000 square feet of floor space for its operations, and a new building is now under construction in Keasbey. One of its kilns for the firing of ferrites is the world's largest for that purpose. All equipment is modern, of high capacity and reliability, and to the greatest possible extent automatic.

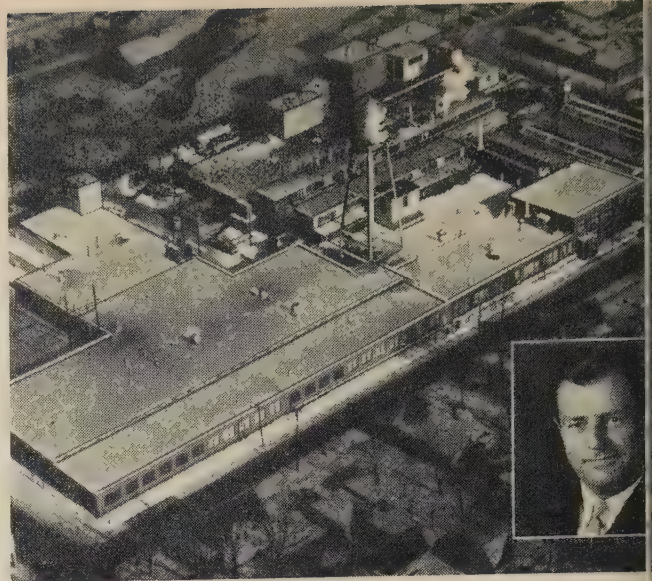
Markets and Sales

Markets are varied and include computers, instruments, radio and television, automotive, military, processing industries, and many others. Indiana General Corp. has several thousand customers. For these reasons, there is no unhealthy dependence on any single market or customer. This stability is valuable to the microwave makers.

Consolidated net sales for 1959 were \$19,865,218, one-third higher than the companies recorded in 1958, before merger. Consolidated net earnings totaled \$1,552,449, or about \$2.76 a share. During the first quarter of 1960 sales and earnings were about 15 per cent above the previous year.

Net working capital rose from \$3,249,802 to \$5,304,483 during 1959, with cash items well above \$2,000,000. Indiana is thus in a strong, liquid position and ready to meet such opportunities and challenges as may develop. This, too, is important to its customers.

The Corporation's 1,124,522 shares of common stock



Plant No. 1 of the Indiana Steel Products Division in Valparaiso, Indiana with inset of Robert F. Smith, president and chief executive officer, Indiana General Corporation.

are listed on the New York Stock Exchange. Indiana, with about 2,800 shareholders, had a two-for-one stock split in June, 1960. The Company has made quarterly dividend payments without interruption since 1950. Since 1936, IGC has paid cash dividends on its common stock in every year except 1939 and 1949.

Management

Robert F. Smith, president, chief executive officer, and a director, joined the company in 1937 as a salesman and rose successively to district sales manager, vice president of sales, vice president and general manager, and in 1953 to president of Indiana Steel. During his tenure as head of the company he acquired Stearns and the Canadian properties and negotiated the merger with General Ceramics. He served in the Navy from 1941 to 1946, leaving active duty with the rank of Commander.

John H. Bouwmeester, executive vice president and director was formerly vice president of manufacturing of Indiana Steel Products. He left to join General Ceramics as executive vice president and later became president assuming his present post upon the merger.

Anthony J. Astrologes, vice president, treasurer and secretary, and a director: came to Indiana in 1948 as an accountant after six years as supervising senior accountant at the Firestone Tire & Rubber Co.

Ivan A. Dickey, vice president, marketing, joined Indiana as head of advertising and sales promotion in 1948 after serving in various marketing capacities at Ampheno Electronics, Inc., and Kellogg Switchboard and Supply Co.

Christopher L. Snyder, vice president, product development was former vice president of General Ceramics Corporation, which he served in various sales, marketing, and engineering capacities since 1939. He is the author of many technical articles.

Dr. Ernst Albers-Schoenberg, vice president, while with Steatit-Magnesia, in Germany, made a major contribution to the development of carbon film resistors and developed magnesium titanates. In this country he de-

developed or directed the development of ferrite memory cores, antenna rods, microwave ferrites, and other materials.

Experiences and Beyond

The most conservative analyst must recognize that magnetism and magnetic materials are an integral part of mid-Twentieth Century society. Short of nuclear devastation, it is impossible to visualize a situation in which the demand for these materials would decrease.

In the case of Indiana General Corp., the combination of aggressive, imaginative, youthful management; high-level scientific talent with an established record of achievement; long experience in all phases of the technology of magnetism; modern plant; strong financial position; and expected demand for its products augur well for the future, barring unpredicted developments.

The Company's primary business is materials and this will probably continue to be the case. There is a definite demand for new and improved materials of increased reliability and lower cost, and on these Indiana is now working. For example, new rotational ferrites for new frequencies and with superior Curie temperature characteristics are now under development.

Indiana is not leaving the future to develop as it will. The Company is planning for greater production, improved products, higher sales, increased profits—in a word, for growth. Its chances of success are, to say the least, optimistic.

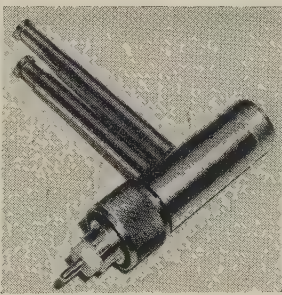
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December, 1960

BRITISH MICROWAVE IN THE U.S.A.



W. H. Sanders (Electronics) Ltd., a leading British supplier of microwave components and test equipment to the European electronics industry, now makes its precision equipment available to the American market. Traditional British craftsmanship coupled with a first class research and development organisation, is presently producing a wide line of equipment and components for the bands 2.60—18.00 kMc/s. Soon to be released are equipments and components for the bands 26.5—40 kMc/s. Research and development is also going forward in the millimetric bands.

A new product of great interest is the stabilized Coaxial Line Oscillator, illustrated. A group of three is available covering the range from 1.3 to 12.4 kMc/s. Stability under carefully controlled laboratory conditions is 1 part in 10^6 , and power output 25 mW min. Each oscillator has its own set level uncalibrated piston attenuator with output taken off through a 50 ohm cable terminated in a Type N connector. The oscillators utilize a low voltage klystron manufactured by the E.M.I. Company of Gt. Britain and can be used with most laboratory klystron supplies.

Through Hoffman Electron Tube Corp., American representatives to the Sanders Group of Companies, a nation wide network of engineering representatives is available to assist you with your requirements. Send for complete technical data on the Coaxial Line Oscillators as well as other precision microwave components manufactured by W. H. Sanders (Electronics) Ltd. Many of the instruments are stocked in the U.S.A. for prompt delivery.



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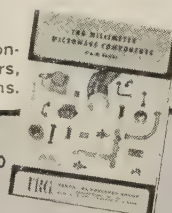
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VSWR: < 1.3 Insertion Loss: < 1.0db
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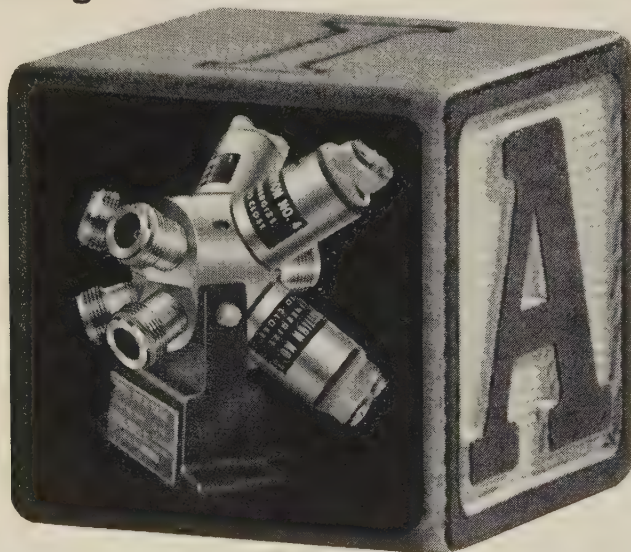
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Industry News

(Continued from page 52)

LORAL ELECTRONICS DEDICATES NEW PLANT



New York Governor Nelson A. Rockefeller, right, and Loral President Leon Alpert unveil a bronze plaque on the new building.

A dedication ceremony was recently held for the new plant and research quarters of Loral Electronics Corp., Colgate and St. Avenues, The Bronx, New York. The speakers were: Governor Nelson A. Rockefeller; Rear Admiral Lawson T. Ramo, Director of Anti-Submarine/Submarine Warfare Division, Office of the Chief of Naval Operations, The Pentagon; and Leon Alpert, Loral president and board chairman.

The addition, adjacent to the company headquarters building, is an 80,000 square foot, two-story structure designed to accommodate Loral's increased staff and accelerated range of research, engineering and production activities. The area's latest electronic facility, Loral now has nine plants with 344,250 square feet of plant and laboratory space in metropolitan New York.

A supplier of electronic systems and equipment to the Department of Defense, Loral was founded in 1948 with a working force of 12 persons.

—mwj—

ADM. N. K. DIETRICH ELECTED HAZELTINE VICE PRESIDENT

Directors of Hazeltine Corp., Little Neck, N.Y., have announced the election of Rear Admiral Neil K. Dietrich, US (Ret.) as a vice president. Admiral Dietrich will be active at the 36-year-old electronics firm's facilities and offices in Little Neck and Washington, D.C. and its other plants throughout the nation.

Prior to joining Hazeltine earlier this month, Admiral Dietrich was Director of Economic Research of the Charleston (S.C.) Development Board. A 1934 graduate of the U.S. Naval Academy, he retired from the Navy in 1958 following a distinguished career. During World War II, he held responsible positions as Assistant Chief of Staff for Logistics with the U.S. Naval Forces Europe and as Aide to Fleet Admiral Ernest J. King. Later he was U. S. Naval Attache at the Naval Attache for Air at the American Embassy in London.

—mwj—

HAROLD A. WHEELER RECEIVES ACHIEVEMENT AWARD

Harold A. Wheeler, a vice president and director of Hazeltine Corp., Little Neck, N. Y., and founder and president of its subsidiary, Wheeler Laboratories, Inc., has received a Distinguished Achievement Award from seven Long Island colleges. He was one of seven prominent scientists to be so honored.

The Award was presented by Adelphi College, Polytechnic Institute of Brooklyn, Hofstra College, Molloy Catholic College for Women, St. Johns University and the U. S. Merchant Marine Academy at a joint Academic Convocation at the Long Island Fair, October 14.

Mr. Wheeler is also a member of the Advisory Group on Radar in the Office of the Secretary of Defense. He is a Fellow of the Institute of Radio Engineers, American Institute of Electrical Engineers and the Radio Club of America, and has been granted about 180 patents relating to radio, television and electronics.

— m w j —

RAYTHEON CONTINUES PRODUCTION ON HAWK MISSILE SYSTEM

Raytheon Company's Missile Systems Division, Waltham, Mass., today was awarded contracts totaling \$29,597,535 by the Boston Ordnance District for continued production and engineering services on the Hawk missile system.

Hawk, the surface-to-air killer developed by Raytheon, is operational with both the U. S. Army and Marine Corps. The sleek, 17-foot long weapon scored history's first kill of a ballistic missile by a guided missile when it destroyed an Honest John early this year at White Sands, N.M. In July, it repeated the feat against the smaller and faster Little John.

The pacts announced today cover production of missiles, battery sets, field maintenance and associated equipment, as well as engineering services. Work will be carried out at Raytheon facilities in Andover, Lowell, North Dighton, Waltham, and Wayland, Mass.; Oxnard, Cal.; and Bristol, Tenn.

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SIGNAL CORPS PURCHASES 35-POUND PORTABLE RADAR SETS

A development contract for radar sets weighing 35 pounds each has been awarded by the U. S. Army Signal Corps, through the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J. The contract issued to Airborne Instruments Laboratory (AIL), a Division of Cutler-Hammer, Inc., Deer Park, N.Y., calls for five service test models at a cost of \$235,000.

The radar's tactical value in detecting the presence of human and mechanized targets under conditions of darkness or blackout is in its aural rather than visual features, but its scales and controls will be visible to the operator under blackout and similar conditions.

The portable radar set, called AN/PPS-5 Short Range Ground Surveillance Radar, is lightweight, miniaturized, transistorized,

combat surveillance radar, battery powered and designed to detect, identify, and locate military moving targets such as enemy personnel and their vehicles. Fletcher H. Moore, chief engineer of AIL's Engineering and Production Division, said that, "the set will detect a moving man at ranges from 150 feet to over 2 miles and a moving 1/4 ton vehicle at ranges from 150 feet to 3 miles.

The total weight of the radar set will not exceed 35 pounds and this includes the electronics, the power supply with provisions for a minimum of 12 hours of sustained power without recharge or replacement, and the tripod.

— m w j —

MANAGEMENT STAFF GAINS TWO ADDITIONS

Two additions to the management staff have been made at the Ground Support Division, American Electronics, Inc., El Monte, Cal., according to D. C. Hammond, Division General Manager.

Wilbert G. Arnold has been promoted to the new post of Director of Procurement and Material. He was formerly Operations Manager of the Division.

William Adler has joined the Ground Support Division as Factory Manager, a new title for Arnold's former duties. Adler has had 21 years of experience in manufacturing, particularly in aircraft, precision machinery and in major components for jet engines and gas turbines. He was Works Manager and Director, Turbo Products, a Division of Poly Industries, Inc., Pacoima, Cal., for the past six years. Previously, Adler was Works Manager of the Calnevar Co., Los Angeles, Cal.

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HALLIGAN NAMED SERVICE MANAGER AT HUGHES

James E. Halligan, Jr., has been named manager of the radar laboratory's field service and support department at Hughes Aircraft Co.'s ground systems group, Culver City, Cal. Dr. Nicholas A. Begovich, assistant group manager announced. Halligan joined Hughes recently upon his retirement from the U. S. Navy as a captain after 30 years service.

During his Navy career Halligan was acting assistant chief of Bureau of Ships for technical logistics, and also served as assistant director of ship design in the bureau. Previous Navy assignments included production officer at Pearl Harbor Naval Shipyard, repair superintendent at Pearl Harbor, and chief engineer of the aircraft carrier U. S. S. Langley during World War II.

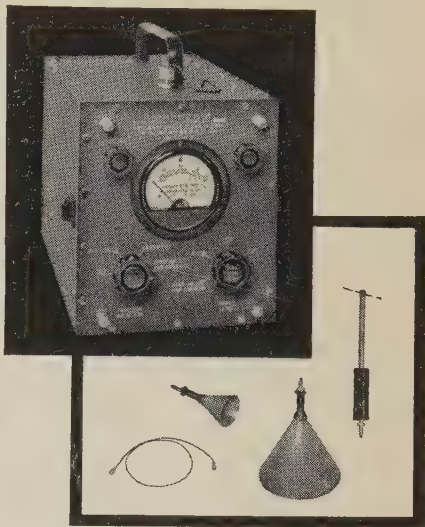
Halligan was graduated from the U. S. Naval Academy in 1934 "with distinction." He received a master of science degree in marine engineering from Massachusetts Institute of Technology in 1943. A native of Boston, he is a member of the Society of Naval Architects and Marine Engineers and American Society of Naval Engineers.

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(Continued on page 110)

BROADBAND POWER DENSITY METER Model NF-157

For fast, accurate determination of RF power density and location of areas presenting RF hazards to personnel



Description: A broadband device providing direct reading of RF power densities from 1 mw/cm² to 1000 mw/cm² (mid-scale readings), over the continuous frequency range from 200 to 10,000 MC.

Features:

- Direct reading of power density insures immediate awareness of hazardous areas.
- Broad frequency range and high accuracy permit universal application to mapping of high level RF fields from VHF to X-Band.
- Accurate built-in step attenuator provides capability of handling power densities over a dynamic range of 10,000 to 1.
- Three constant-gain calibrated probes permit direct reading in mw/cm² over the continuous frequency range from 200 to 10,000 MC.
- Physical separation of probes from main unit vastly increases flexibility of applications.
- Battery-powered, light-weight design permits complete portability.
- Convenient carrying case simplifies transportation of instrument.
- Efficient shielding prevents stray RF pickup.
- Conservative design insures resistance to over-load.
- Main unit may be used independently as an accurate, rugged RF power meter over a wide power range.



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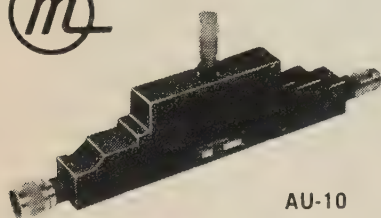
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Tested in the field. The AU-10, modified for high power, continuously withstood 100 watts of CW power for 24 hours, reliably maintaining its performance characteristics. Other electrical parameters are essentially those of the standard AU-10.

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Industry News

(Continued from page 109)

DR. ZVI PRIHAR NAMED DIRECTOR AT PAGE

Dr. Zvi Prihar, former Professor of Electrical Engineering at the University of Wichita, Kansas, has been appointed an Assistant Director of Telecommunications at Page Communications Engineers, Inc., Washington, D.C.

Prior to his academic activities, Dr. Prihar was, during 1953-1957, Consulting Engineer and later Administrator Special Studies - Communications with RCA, in their RCA International Division. His duties there included planning of telecommunications projects, special studies, foreign assignments, field surveys, and engineering consulting services. He served as Director General and Chief Engineer (Postmaster General) for the State of Israel from 1948 to 1951.

Dr. Prihar received his Doctor of Engineering Science degree (Eng. Sc. D.) from Columbia University. He is a registered professional engineer (P.E.) with the state of Kansas; a senior member of the Institute of Radio Engineers and a Member of the Institution of Electrical Engineers (British).

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BERNARD HERMAN NAMED MANAGER OF OPERATIONS AT LORAL

Bernard Herman has been promoted to Manager of Operations, a new position, it was announced today by Edward J. Garrett, Vice President and General Manager, Loral Electronics Corporation, New York, N.Y. In his new post, Mr. Herman will be responsible for the supervision and coordination of operating activities of the company's seven autonomous divisions.

Mr. Herman joined Loral in 1950. Since 1957 he has been Director of Industrial Engineering and in 1959 was elected Assistant Secretary of the corporation. He holds a B.S. degree from Cornell University.

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MELPAR DELIVERS 23 ANTENNAS FOR PROJECT MERCURY

Melpar, Inc., Falls Church, Va., has delivered 23 beacon antenna systems to Collins Radio Co. for use with the communications sub-system being supplied for the manned orbital "Mercury" space capsule.

The capsule was developed by McDonnell Aircraft Corp. The antenna systems provide circularly-polarized, omnidirectional radiation coverage which is optimum for reliable lock-on of ground-based tracking antennas.

Forming part of the missile or space vehicle skin, the electromagnetic antenna windows are transparent to radio signals, yet can stand the extreme heat of re-entry into the atmosphere.

The beacon antennas were specially designed to withstand surface temperatures of 5000°F (approximately half the temperature of the sun's surface) for several

seconds, and 1500°F for longer periods. The systems include both C-band and X-band antennas, each antenna consisting of a circularly-polarized helical radiator embedded in fused quartz dielectric.

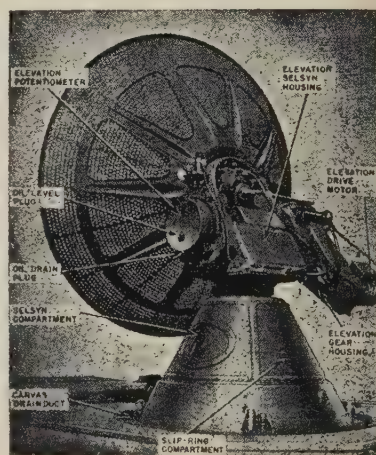
This high-temperature, low-loss dielectric reduces size, provides thermal shielding, minimizes voltage breakdown, and provides a window for transmission. The antennas have been exposed to every conceivable stress expected during the capsule's flight program and have demonstrated an ability to withstand environmental conditions exceeding the design requirement.

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WILLIAM CLOUD JOINS VARIAN ASSOCIATES

William W. Cloud has been appointed to the Washington office staff of Varian Associates, Palo Alto, Cal., President Myrl Stearns announced today. Cloud will assist Col. Walter Brown, manager of Varian's Washington office, in maintaining contact with procurement branches of the various military and civilian agencies.

Holder of a number of patents for electrical and electronic devices, Cloud has spent the last several years in France as consulting engineer to such firms as Compagnie Francaise Thomson Houston and Decca Radar, Ltd., of England. Cloud, native of Dell Rapids, S.D., was trained in the U.S. Navy's radar school during



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the microwave journal

World War II. After the war he joined Westinghouse Electric Corporation, which eventually sent him to England to advise on the installation of U.S.-built radar in British jet fighters.

Cloud later was sent to France on a similar mission, one that eventually required redesigning major portions of the French aircraft to make the radar effective. He remained in France to handle Westinghouse's defense relations with NATO, SHAPE and the U.S. European Command. Cloud left Westinghouse in 1956 to become a consulting engineer for European industry.

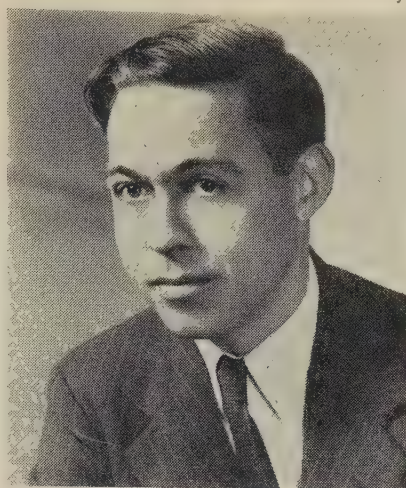
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DAMON JOINS MICROWAVE ASSOCIATES

Microwave Associates, Inc., Burlington, Mass., announces the appointment of Dr. Richard W. Damon as Director of a Research and Development Group on microwave solid-state control devices. In this newly created position, Dr. Damon will be working on new microwave devices utilizing ferrites and semiconductors, and on novel techniques employing these materials. He will report directly to Dr. Lawrence Gould, vice president and Director of the Tube Division. This appointment is in keeping with Microwave Associates' recent expansion of its Tube Division Research and Development section in both personnel and research capabilities.

Dr. Damon was a research physicist with General Electric Co.'s Research

Laboratory in Schenectady, N. Y. prior to joining Microwave Associates. His work at G. E. included studies of ferromagnetic resonance, photoconductivity,



and television camera tube principles. He has published many professional papers in these fields.

Dr. Damon received his BS (1944), MA (1947), and his PhD (1951) degrees in Applied Physics from Harvard University. During World War II he served with the United States Navy as a Sonar Officer in the Pacific (Philippines).

He is a member of the American Physical Society, the American Association for the Advancement of Science (AAAS), and Sigma Xi.

— m w j —

ANTENNA SYSTEMS ANNOUNCES THREE APPOINTMENTS

Antenna Systems, Inc., Hingham Industrial Center, Hingham, Mass., announces the following appointments: Ansel J. Gere, Antenna Engineer; Deane A. Beytes, Project Engineer; and Andre M. Castellano, Quality Control Manager.

Mr. Gere received his BS from Massachusetts Institute of Technology, and has had extensive experience in designing antennas and microwave components. Prior to joining ASI, he has worked at General Electronic Laboratory, Diamond Antenna and Microwave, Gabriel Electronics, and the Rand Corporation. He is a registered professional engineer in Massachusetts, and a member of the IRE.

Mr. Beytes received his BS in physics from Massachusetts State College, and SB in Mechanical Engineering from Massachusetts Institute of Technology. He comes to ASI from Pitney-Bowes, Inc. where he was an engineer and project supervisor.

Mr. Castellano has an AS, BBA, and MBA in Industrial and Engineering Management from Northeastern University. He has had extensive quality control experience in the antenna field, and for the past seven years has been associated with Gabriel Electronics as Quality Control Manager. In his new position at ASI, Mr. Castellano will be manager of Quality Control.

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(Continued on page 112)

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VERSATILE LABORATORY AND PRODUCTION UNITS FOR . . .

- Accurate measurement of peak voltage.
- Critical viewing of pulse shape from magnetrons, pulse forming networks, driver amplifiers and radar modulators.
- Measuring pulse signals of 1/4 to 10 microseconds duration or continuous wave frequencies from 5000 cycles to 10 megacycles per second.
- Use with any synchroscope or cathode ray oscilloscope with trigger delay circuit and an input resistance of 300,000 ohms or more with a shunt capacity of approximately 30 mmf.

FEATURES

- Extremely Wide Voltage Range 250 to 100,000 Peak Volts
- Capacitance Type — Low Dissipation
- High Stability
- Division Ratios 500:1 100:1 and 10:1
- Accuracy $\pm 5\%$
- Light Weight — 10 1/2 pounds (Less Transit Case and Accessories)

MODEL VD-35

FEATURES

- 35,000 Peak Volts
- Capacitance Type — Low Dissipation
- Division Ratios 200:1 and 50:1
- Accuracy $\pm 5\%$
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WATERS APPOINTED SECTION HEAD



The appointment of Dr. William F. Waters as an engineering section head at Microwave Electronics Corp., Palo Alto, Cal. has been announced by Dr. Stanley F. Kaisel, president.

Dr. Waters came from 12 years of high level government service. Starting in 1948 with the National Bureau of Standards, he did research and development on microwave tubes for use in guided missiles.

He transferred to Diamond Ordnance

Fuze Laboratories at its founding in September of 1953, where his initial activity was in the development of microwave oscillators for proximity-fuze transmitters. In late 1956 he was appointed chief of the Microwave Tube Section of DOFL and in mid-1958 he was made research supervisor with cognizance over microwave tube research and development.

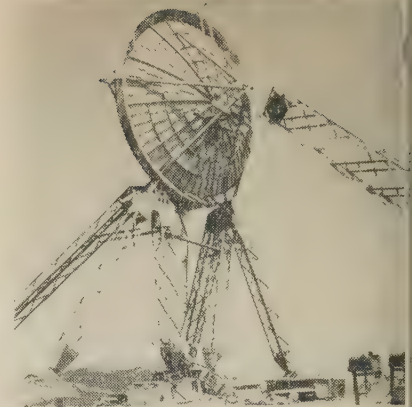
A native Kentuckian, Dr. Waters has a BS degree in Electrical Engineering and an MS degree in Physics from the University of Kentucky. His doctorate is from the University of Maryland. He held a Secretary of the Army Study Fellowship at Stanford University during 1958-59, working on advanced theories in microwave tube developments.

He is a member of the Institute of Radio Engineers and of the IRE's Professional Group on Electron Devices. His memberships also include the American Physical Society, the American Association for the Advancement of Science and the Federation of Atomic Scientists.

—mwj—

"ACE HIGH" ANTENNA NETWORK BEGUN

Specially designed for NATO by the Special Products division of ITE Circuit Breaker Co., Philadelphia, Pa., the first of 160 huge antenna dishes, designed to give NATO the world's most extensive scatter-type radio communications system, recently were completed in Turkey. The network, appropriately named "Ace High," will link member nations from southern Turkey to northern Norway.



Forward-scatter transmission — the beaming of ultra-high frequency signals at tropospheric or ionospheric layers which, in turn, reflect the energy groundward to predetermined points — will be used. Fast and reliable, this type of communication can be utilized far beyond the horizon — up to 250 miles by tropospheric scatter and 1,300 miles by ionospheric.

The solid steel antennas range from 30 to 60 feet in diameter. Because of the size and weight of the antennas making overseas shipment impractical, ITE is working with the West German firm Krupp, Maschinen und Stahlbau, Rheinfelden, to build the dishes and supporting structures.

ITE will complete installation of the six million dollar antenna project by 1961.

—mwj—

SANDERS RECEIVES ADDITIONAL FUNDING FROM BENDIX

Sanders Associates, Inc., Nashua, N.H. has received additional funding of \$1,100,000 in a contract from the Bendix Corporation for the next phase of its development program for the Eagle Missile Seeker System.

Royden C. Sanders, Jr., president, disclosed that the research and development phase for the seeker device has reached successful completion. The program now enters the preproduction design stage, he said.

The Bendix Corporation, Systems Manager, heads a seven company team for development of the Eagle air-to-air missile and associated fire control. Douglas Aircraft is the prime contractor for developing and producing the recently announced Missileer Launcher Aircraft for the Eagle System. The Eagle-Missileer Program will run over a period of several years.

As a member of the Bendix Eagle Team Sanders has the assignment of the target seeking device for the high-performance Missile. High performance is being built into the missile in order to reduce the cost and complexity of the launching aircraft which is designed for staying power and for operation at high altitudes. Eagle capabilities, as specified by the Navy, will be to destroy any enemy aerodynamic guided missile or aircraft now in operation or expected in the foreseeable future.

—mwj—



Can you reduce celestial noise in a space communications system? Can you utilize it? Can you advance the state of the art in pictorial data transmission and storage, pattern recognition, synchronization techniques, data compression, or coding theory? If you feel you can make original contributions in any of these areas, contact Mr. Harry Laur at our Advanced Development Laboratory, 221 Crescent Street, Waltham, Massachusetts.



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You are invited to investigate now by writing to Dr. J. S. Needle at the address below. (Similar opportunities in the field of magnetrons and special purpose tubes also exist at the Microwave Device Operations in Williamsport, Pennsylvania.)

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NEW LITERATURE

MICROWAVE FREQUENCY MULTIPLIER DESCRIBED

Gertsch Products, Inc., Los Angeles Cal., has prepared a two-page data sheet which describes a phase-locked oscillator capable of transferring the accuracy and stability of a VHF driver into the micro-region of 500 to 30,000 Mcs. The unit has a fundamental frequency range of 500 to 1000 Mcs, with output to at least 30,000 Mcs available from an external harmonic generator-mixer furnished as standard equipment.

Included in the bulletin are complete specifications and product illustrations. Designated as Model FM-4A, this instrument can be used with the Gertsch Models FM-3, -6, and -7, as a driver. The unit measures and generates frequencies with accuracy and stability equal to that of the driving source.

The FM-4A is completely self-contained, can be operated directly from 115 or 230 volts, 50/60 cycles. It is housed in an aluminum carrying case which measures 16 inches x 12 inches x 21.5 inches, and weighs approximately 40 lbs. Adapters for rack mounting are supplied as standard.

Circle Reader Service Card 136

— m w j —

SHORT FORM CATALOG RELEASED BY HUGGINS

A new two-color short form catalog of production traveling-wave tubes has just been released by Huggins Laboratories, Inc., of Sunnyvale, Cal. Listed in the catalog is Huggins' line of over 85 basic tube types covering the VHF through Ku-bands, along with pertinent tube character-

istics, prices, delivery quotations, and local sales representatives.

The catalog illustrates the many types TWTs manufactured to cover a variety of applications. Included in the list are low noise amplifiers; solenoid, PPM, and electrostatically focused forward-wave amplifiers; voltage tuned backward-wave amplifiers and oscillators; and special purpose tubes.

Circle Reader Service Card 137

— m w j —

FOUR-PAGE BULLETIN OFFERED BY ALDEN

A four-page technical bulletin describing a new modular helix graphic recording system, Alden Model 305 GPL, is available on request from the Alden Electronic Impulse Recording Equipment Co., Inc., Westboro, Mass.

Fully-documented, sepia-tone photographs of typical recordings that can be obtained with new modular recording system are included in the brochure to illustrate both the versatility and the high resolution capabilities of the Alden Model 305 GPL. The recordings show are of low frequency atmospheric whistlers, radar ionospheric back-scatter returns, sonar returns from microscopic sea life at 100 fathom intervals and continuous temperature profiles of the Gulf Stream.

The bulletin also contains complete technical data on the recording system as well as physical specifications, data on accessories, and ordering information.

Circle Reader Service Card 138

(Continued on page 116)

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FINANCIAL NEWS

NARDA REPORTS SALES, PROFIT INCREASE

In its annual report to stockholders, the Narda Microwave Corp., Mineola, N. Y. reports that sales for the fiscal year (ended June 30, 1960) were up 47 per cent to \$2,250,000 over last year. At the same time, the company announced that profits this year rose to \$65,000, a 12 per cent increase over the previous year.

Costs and expenses increased less than proportionately to sales except Research and Development costs, which were about 2 1/2 times the previous year's. This added R and D expense has resulted in the introduction of a number of new product groups expected to make important contributions to further sales expansion.

Narda is seeking a suitable site on Long Island on which to construct a single modern plant building with facilities and space adequate for the company's growth. This move is planned for the summer of 1961.

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SANDERS REPORTS NET EARNING AT ALL-TIME HIGH

Sanders Associates, Inc., Nashua, N. H. has reported final figures for the fiscal year ending July 31, 1960 show net earnings at an all-time high of \$1.06 per share. This compares with 85 cents per share a year ago. Total net earnings rose to \$458,186, an increase of 40 per cent over a year ago.

Total sales for fiscal 1960 rose 64 per cent from last year to a record \$17,230,365, compared with \$10,562,817 for 1959.

"In looking at the year ahead, we foresee the largest dollar volume rise in our history with sales for the fiscal year going over the \$25 million mark," said president Royden C. Sanders, Jr. "This would be more than a 50 per cent rise and would continue our record of doubling sales every two years," he said.

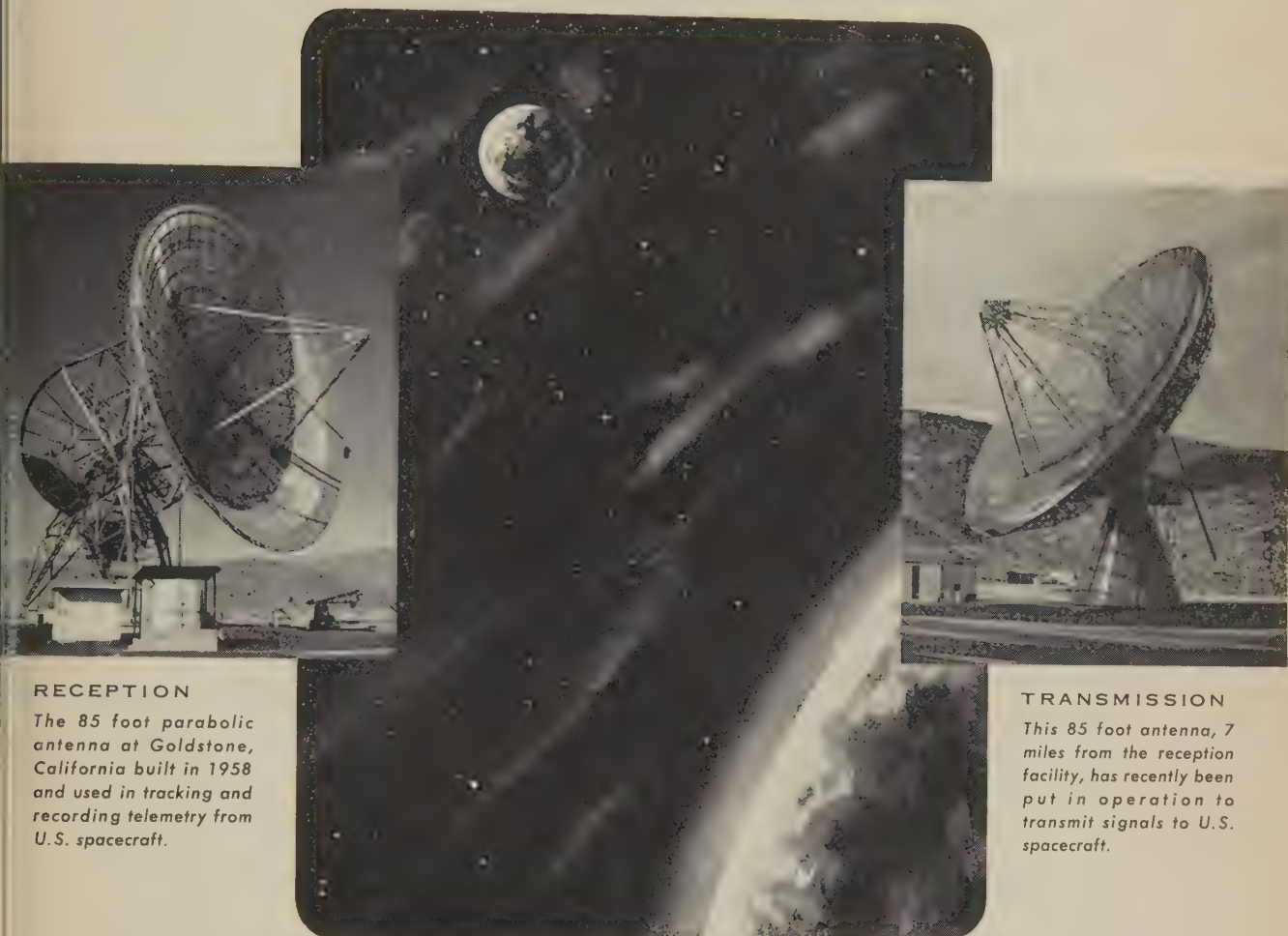
The \$1.06 earnings per share are based on 431,316 shares outstanding previous to the special 100 per cent stock dividend recently voted by Sanders' Board of Directors.

— m w j —

the microwave journal

Pioneering Achievements at JPL

Following an impressive period, beginning in 1938, in the pioneering and development of all forms of rocketry—JPL's jump into outer space began with the successful flight of America's first satellite, Explorer I. When the moon probes Pioneer III and IV proved equally successful, the Jet Propulsion Laboratory's position as an outstanding center of research and development was again confirmed.



RECEPTION

The 85 foot parabolic antenna at Goldstone, California built in 1958 and used in tracking and recording telemetry from U.S. spacecraft.

TRANSMISSION

This 85 foot antenna, 7 miles from the reception facility, has recently been put in operation to transmit signals to U.S. spacecraft.

PIONEERING IN SPACECRAFT COMMUNICATIONS

With the completion of the new transmitting antenna installation at the Goldstone Deep Space Instrumentation Facility in California, a unique space communications research and operations laboratory now exists which makes possible still further communications achievements in space research. The facility is being used in various ways. Two-way communications with space probes permits precision tracking, precision radio guidance, and wideband data reception. Working as a bistatic, CW Doppler radar, the facility permits

accurate tracking of dark satellites whose orbits are only imperfectly known, as well as accurate tracking of the moon and, later, the planets.

The purely scientific data produced by such a facility ranges from propagation data and lunar reflectivity characteristics to the wideband data communicated to the station from the scientific instruments aboard the space probes. This is but one of the many space exploration activities pioneered by the Jet Propulsion Laboratory.



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New Literature

(Continued from page 114)

BULLETIN LISTS TYPE A DESICCANT DRYERS

A new technical Bulletin #A-309, listing and describing standard Type A desiccant dryers is now available upon request from Trinity Equipment Corp., Cortland, N.Y. The bulletin lists sizing information, as well as operational and mechanical specifications on the wide range of Type A dryers available from Trinity.

The Trinity Type A dynamic desiccant dryer employs electric, or steam upon special order, heaters to reactivate the desiccant chambers.

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NEW BROCHURE DESCRIBES PHOTO-ETCHED MICROWAVE CIRCUITS

A new four-page brochure describing advanced design photo-etched microwave circuit modules is available on request from the Instrument Division of Laboratory for Electronics, Inc., Boston, Mass. The technical brochure gives complete specification and application data about the LFE division's new Epsilone standard photo-etched circuit packages, which include balanced crystal mixers, directional couplers and power dividers.

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NEW POTENTIOMETER CATALOG ANNOUNCED BY SPECTROL

A new two-color, six-page brochure, outlining precision wire wound potentiometers and turns counting dials is now available from Spectrol Electronics Corp., San Gabriel, Cal., manufacturer of precision electronic components.

The brochure contains complete technical specifications and dimensioned mounting diagrams for all models of precision potentiometers and turns counting dials that are stocked locally for immediate delivery at distributors throughout the U. S. and Canada.

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SUPERIOR OFFERS 10-PAGE PRODUCT GUIDE

A 10-page guide to the most frequently ordered products of The Superior Electric Co., Bristol, Conn. is now available on request. It is small enough to fit easily into a desk file or three-ring binder.

Covers ratings and other essential technical data on Powerstat Variable Transformers, Stabiline Automatic Voltage Regulators, Supercon Electrical Connectors, Superior 5-Way Binding Posts, Dub-L-Plug Dual Electrical Connectors, Slo-Syn Synchronous Motors, Flexiformer Packaged Transformer Primaries, Powerstat Decade Line Correctors, Exel Loading Reactors, Varicell Adjustable A-C/D-C Power Supplies are shown.

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CALIFORNIA

FREQUENCY METER DATA SHEET PUBLISHED BY GERTSCH

A two-color data sheet from Gertsch Products, Inc., Los Angeles, Cal., describes a continuously variable frequency meter designed to measure and generate over a frequency range from 20 to 1000 Hz, with guaranteed accuracy of 0.0001%. It will maintain any generated frequency within its range with a stability of 0.0001%. Both AM and FM modulation are supplied.

Also included in the data sheet are detailed technical specifications, and product illustrations. Designated as model FM-7, this instrument meets the FCC tolerance requirement of $\pm 0.0005\%$ with a minimum safety factor of five to one. When combined with the DM-3 deviation meter and RFA-1 attenuator, unit provides a complete communication service package. Both portable and rack mounted versions are available.

Circle Reader Service Card 143

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APPLICATION NOTE #5 RELEASED BY WEINSCHTEL

Weinschel Engineering, Kensington, Md., has just released Application Note #5, "Microwave Antenna Pattern Measurements with the BA-7 Video Crystal Receiver."

This 12-page, two-color brochure describes simple antenna pattern measuring instrumentation based upon the Weinschel Model BA-7 Video Crystal Receiver. Because of the simplicity of the video crystal receiver and the low-power RF sources required, this particular type of instrumentation is lower in cost, smaller in size and weight, easier to operate and of equal or broader frequency coverage than instruments based upon either barretter or heterodyne receivers. Copies of Application Note #5 are available upon request.

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RELAY MANUFACTURERS' PUBLICATION ANNOUNCED

The National Association of Relay Manufacturers announces the availability of a publication incorporating all of the papers presented at the Eighth Annual Relay Conference which was held in Stillwater, Oklahoma, May 3 to 5, 1960. Titled "Electro-Magnetic Relays: Compilation of Papers Presented at the Eighth Annual Relay Symposium at Stillwater," the report can be obtained on request.

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NEW CATALOG SUPPLEMENT RELEASED BY LEL

LEL, Inc., Copiague, N.Y., recently released a supplement to its Catalog No. 1, which gives specifications on several new products including microwave mixer-amplifiers, a telemetry preamplifier, a miniature command receiver, precision laboratory receiver and solid-state microwave receiver.

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December, 1960

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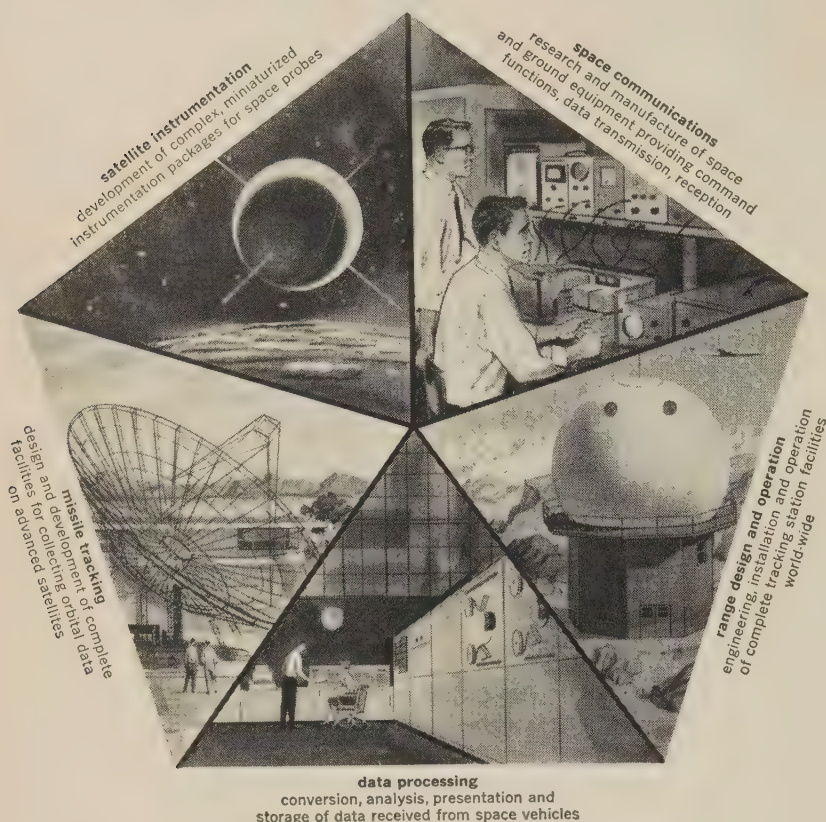
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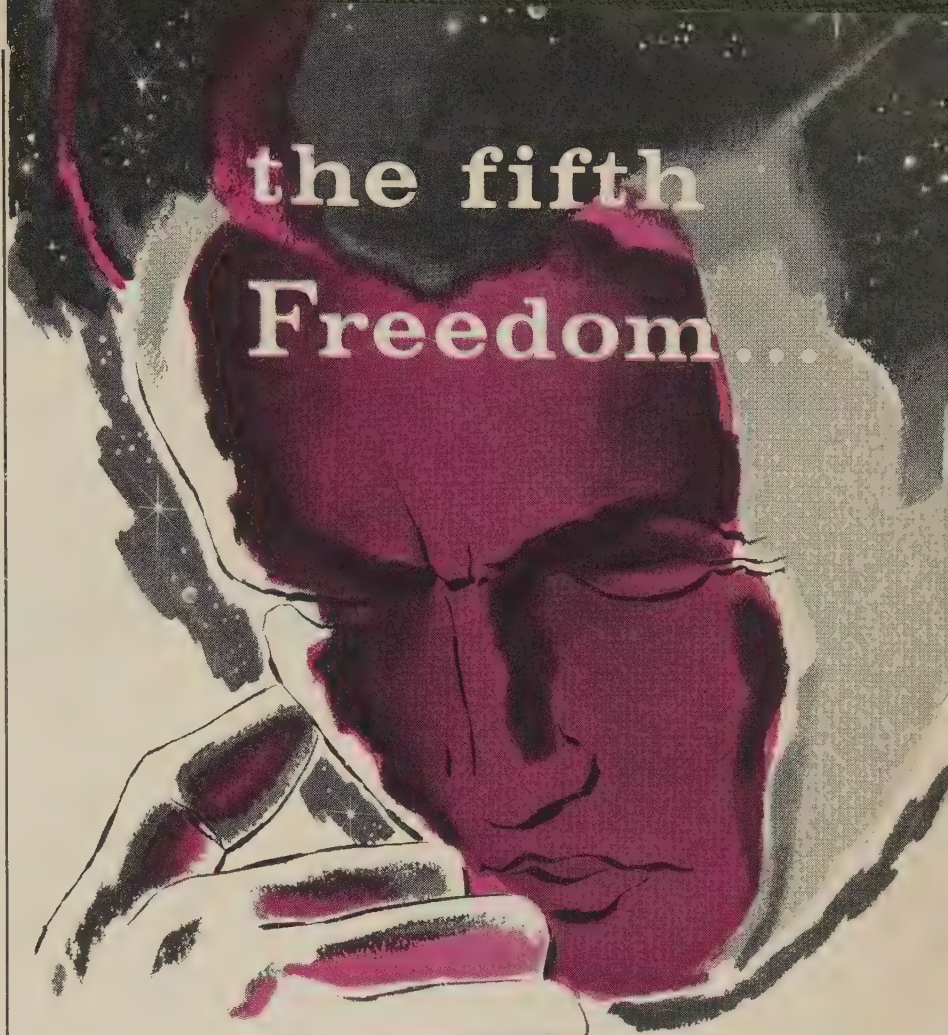
We wish to emphasize again that "the journal" is interested in receiving papers from the industry.

Papers can be addressed to: "the microwave journal," 1330 Beacon St., Brookline, Mass.

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When submitting a change of address, please complete the subscription card inside the back cover of the magazine. Include the address at which you have been receiving the microwave journal, and allow one month for the change to become effective.



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TOTALLY DEVOID OF MARKETING EFFORT"

MARKETING Myopia

BY

THEODORE LEVITT

The first installment of this article, which appeared in the November issue, dealt with product obsolescence and the characteristics of a "growth industry." The second and final installment looks at the field of electronics and reviews customer orientation. The article is condensed from the July/August issue of the "Harvard Business Review."

PART II

The best way for a firm to be lucky is to make its own luck. That requires knowing what makes a business successful. One of the greatest enemies of this knowledge is mass production.

Production Pressures

Mass-production industries are impelled by a great drive to produce all they can. The prospect of steeply declining unit costs as output rises is more than most companies can usually resist. The profit possibilities look spectacular. All effort focuses on production. The result is that marketing gets neglected.

John Kenneth Galbraith contends that just the opposite occurs.⁴ Output is so prodigious that all effort concentrates on trying to get rid of it. He says this accounts for singing commercials, desecration of the countryside with advertising signs, and other wasteful and vulgar practices. Galbraith has a finger on something real, but he misses the strategic point. Mass production does indeed generate great pressure to "move" the product. But what usually gets emphasized is selling, not marketing. Marketing, be-

ing a more sophisticated and complex process, gets ignored.

The difference between marketing and selling is more than semantic. Selling focuses on the needs of the seller; marketing on the needs of the buyer. Selling is preoccupied with the seller's need to convert his product into cash; marketing with the idea of satisfying the needs of the customer by means of the product and the whole cluster of things associated with creating, delivering, and finally consuming it.

In some industries the enticements of full mass production have been so powerful that for many years top management in effect has told the sales departments "You get rid of it; we'll worry about profits." By contrast, a truly marketing-minded firm tries to create value-satisfying goods and services that consumers will want to buy. What it offers for sale includes not only the generic product or service, but also how it is made available to the customer, in what form, when, under what conditions, and at what terms of trade. Most important, what it offers for sale is determined not by the seller but by the buyer. The seller takes his cues from the buyer in such a way that the product becomes a consequence of the marketing effort, not vice versa.

Dangers of R & D

Another big danger to a firm's continued growth arises when top management is wholly transfixed by the profit possibilities of technical research and development. To illustrate I shall turn first to a new industry — electronics.

Marketing Shortchanged

In the case of electronics, the greatest danger which faces the glamorous new companies in this field is not

⁴ *The Affluent Society* (Boston, Houghton Mifflin Company 1958), pp. 152-160.

that they do not pay enough attention to research and development, but that they pay *too much* attention to it. And the fact that the fastest growing electronics firms owe their eminence to their heavy emphasis on technical research is completely beside the point. They have vaulted to affluence on a sudden crest of unusually strong general receptiveness to new technical ideas. Also, their success has been shaped in the virtually guaranteed market of military subsidies and by military orders that in many cases actually preceded the existence of facilities to make the products. Their expansion has, in other words, been almost totally devoid of marketing effort.

Thus, they are growing up under conditions that come dangerously close to creating the illusion that a superior product will sell itself. Having created a successful company by making a superior product, it is not surprising that management continues to be oriented toward the product rather than the people who consume it. It develops the philosophy that continued growth is a matter of continued product innovation and improvement.

A number of other factors tend to strengthen and sustain this belief:

(1) Because electronic products are highly complex and sophisticated, managements become top-heavy with engineers and scientists. This creates a selective bias in favor of research and production at the expense of marketing. The organization tends to view itself as making things rather than satisfying customer needs. Marketing gets treated as a residual activity, "something else" that must be done once the vital job of product creation and production is completed.

(2) To this bias in favor of product research, development, and production is added the bias in favor of dealing with controllable variables. Engineers and scientists are at home in the world of concrete things like machines, test tubes, production lines, and even balance sheets. The abstractions to which they feel kindly are those which are testable or manipulatable in the laboratory, or, if not testable, then functional, such as Euclid's axioms. In short, the managements of the new glamour-growth companies tend to favor those business activities which lend themselves to careful study, experimentation, and control—the hard, practical, realities of the lab, the shop, the books.

What gets shortchanged are the realities of the market. Consumers are unpredictable, varied, fickle, stupid, shortsighted, stubborn, and generally bothersome. This is not what the engineer-managers say, but deep down in their consciousness it is what they believe. And this accounts for their concentrating on what they know and what they can control, namely, product research, engineering, and production. The emphasis on production becomes particularly attractive when the product can be made at declining unit costs. There is no more inviting way of making money than by running the plant full blast.

Today the top-heavy science-engineering-production orientation of so many electronics companies works reasonably well because they are pushing into new frontiers in which the armed services have pioneered virtually assured markets. The companies are in the felicitous position of having to fill, not find markets; of not having to discover what the customer needs and wants, but of having the

customer voluntarily come forward with specific new product demands. If a team of consultants had been assigned specifically to design a business situation calculated to prevent the emergence and development of a customer-oriented marketing viewpoint, it could not have produced anything better than the conditions just described.

Beginning & End

The view that an industry is a customer-satisfying process, not a goods-producing process, is vital for all businessmen to understand. An industry begins with the customer and his needs, not with a patent, a raw material, or a selling skill. Given the customer's needs, the industry develops backwards, first concerning itself with the physical *delivery* of customer satisfactions. Then it moves back further to *creating* the things by which these satisfactions are in part achieved. How these materials are created is a matter of indifference to the customer, hence the particular form of manufacturing, processing, or what-have-you cannot be considered as a vital aspect of the industry. Finally, the industry moves back still further to *finding* the raw materials necessary for making its products.

The irony of some industries oriented toward technical research and development is that the scientists who occupy the high executive positions are totally unscientific when it comes to defining their companies' overall needs and purposes. They violate the first two rules of the scientific method—being aware of and defining their companies' problems, and then developing testable hypotheses about solving them. They are scientific only about the convenient things, such as laboratory and product experiments. The reason that the customer (and the satisfaction of his deepest needs) is not considered as being "the problem" is not because there is any certain belief that no such problem exists, but because an organizational lifetime has conditioned management to look in the opposite direction. Marketing is a stepchild.

I do not mean that selling is ignored. Far from it. But selling, again, is not marketing. As already pointed out, selling concerns itself with the tricks and techniques of getting people to exchange their cash for your product. It is not concerned with the values that the exchange is all about. And it does not, as marketing invariably does, view the entire business process as consisting of a tightly integrated effort to discover, create, arouse, and satisfy customer needs. The customer is somebody "out there" who, with proper cunning, can be separated from his loose change.

Actually, not even selling gets much attention in some technologically minded firms. Because there is a virtually guaranteed market for the abundant flow of their new products, they do not actually know what a real market is. It is as if they lived in a planned economy, moving their product routinely from factory to retail outlet. Their successful concentration on products tends to convince them of the soundness of what they have been doing, and they fail to see the gathering clouds over the market.

Conclusion

Less than 75 years ago American railroads enjoyed a fierce loyalty among astute Wall Streeters. European monarchs invested in them heavily. Eternal wealth was

thought to be the benediction for anybody who could scrape a few thousand dollars together to put into rail stocks. No other form of transportation could compete with the railroads in speed, flexibility, durability, economy, and growth potentials. As Jacques Barzun put it, "By the turn of the century it was an institution, an image of man, a tradition, a code of honor, a source of poetry, a nursery of boyhood desires, a sublimest of toys, and the most solemn machine—next to the funeral hearse—that marks the epochs in man's life."

Even after the advent of automobiles, trucks, and airplanes, the railroad tycoons remained imperturbably self-confident. If you had told them 60 years ago that in 30 years they would be flat on their backs, broke, and pleading for government subsidies, they would have thought you totally demented. Such a future was simply not considered possible. It was not even a discussable subject, or an askable question, or a matter which any sane person would consider worth speculating about. The very thought was insane. Yet a lot of insane notions now have matter-of-fact acceptance—for example, the idea of 100-ton tubes of metal moving smoothly through the air 20,000 feet above the earth, loaded with 100 sane and solid citizens casually drinking martinis—and they have dealt cruel blows to the railroads.

What specifically must other companies do to avoid this fate? What does customer orientation involve? These questions have in part been answered by the preceding examples and analysis. It would take another article to show in detail what is required for specific industries. In any case, it should be obvious that building an effective customer-oriented company involves far more than good intentions or promotional tricks; it involves profound matters of human organization and leadership. For the present, let me merely suggest what appear to be some general requirements.

Visceral Feel of Greatness

Obviously the company has to do what survival de-

mands. It has to adapt to the requirements of the market and it has to do it sooner rather than later. But mere survival is a so-so aspiration. Anybody can survive in some way or other, even the skid-row bum. The trick is to survive gallantly, to feel the surging impulse of commercial mastery; not just to experience the sweet smell of success but to have the visceral feel of entrepreneurial greatness.

No organization can achieve greatness without a vigorous leader who is driven onward by his own pulsating *will to succeed*. He has to have a vision of grandeur, a vision that can produce eager followers in vast numbers. In business, the followers are the customers. To produce these customers, the entire corporation must be viewed as a customer-creating and customer-satisfying organism. Management must think of itself not as producing products but as providing customer-creating value satisfactions. It must push this idea (and everything it means and requires) into every nook and cranny of the organization. It has to do this continuously and with the kind of flair that excites and stimulates the people in it. Otherwise, the company will be merely a series of pigeonhole parts, with no consolidating sense of purpose or direction.

In short, the organization must learn to think of itself not as producing goods or services but as *buying customers*, as doing the things that will make people *want* to do business with it. And the chief executive himself has the inescapable responsibility for creating this environment, this viewpoint, this attitude, this aspiration. He himself must set the company's style, its direction, and its goals. This means he has to know precisely where he himself wants to go, and to make sure the whole organization is enthusiastically aware of where that is. This is a first requisite of leadership, for *unless he knows where he is going, any road will take him there*.

If any road is okay, the chief executive might as well pack his attaché case and go fishing. If an organization does not know or care where it is going, it does not need to advertise that fact with a ceremonial figurehead. Everybody will notice it soon enough.

A NOTE TO INDUSTRY MANUFACTURERS

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The publishers of *the microwave journal* invite your participation in the microwave handbook and catalogue now being prepared for publication.

We are presently collecting charts, nomographs, graphs, tables, etc., all devoted to microwaves which will be a great service to our readers. It has been demonstrated that the microwave engineer is either inadequately served or his field of interest is handled as a small part of the entire electronics field.

We are now in the process of collecting and editing as much useful information as possible, which pertains specifically to microwaves including VHF, UHF and millimeter waves. Many manufacturers have compiled useful data which have been promised for this handbook. In addition to the technical information, we expect to

have a complete microwave directory of manufacturers and products.

It is planned that the microwave handbook and catalogue will be published on an annual basis beginning with our first edition in the summer of 1961. With each succeeding year, we will revise, expand, and improve the handbook section.

Your careful attention to our questionnaire will be of great value in the preparation of this industry directory. This questionnaire, certainly, will benefit you, the manufacturer, in that your firm and its products will be effectively presented to the industry through the pages of "the microwave engineers' handbook and buyers' guide."

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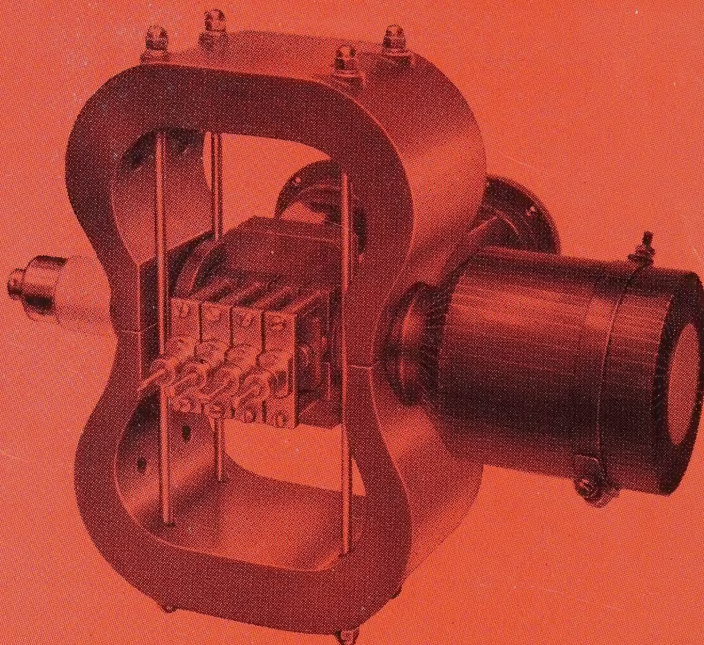
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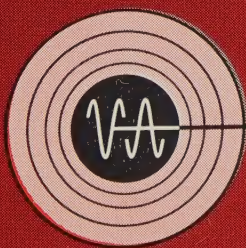
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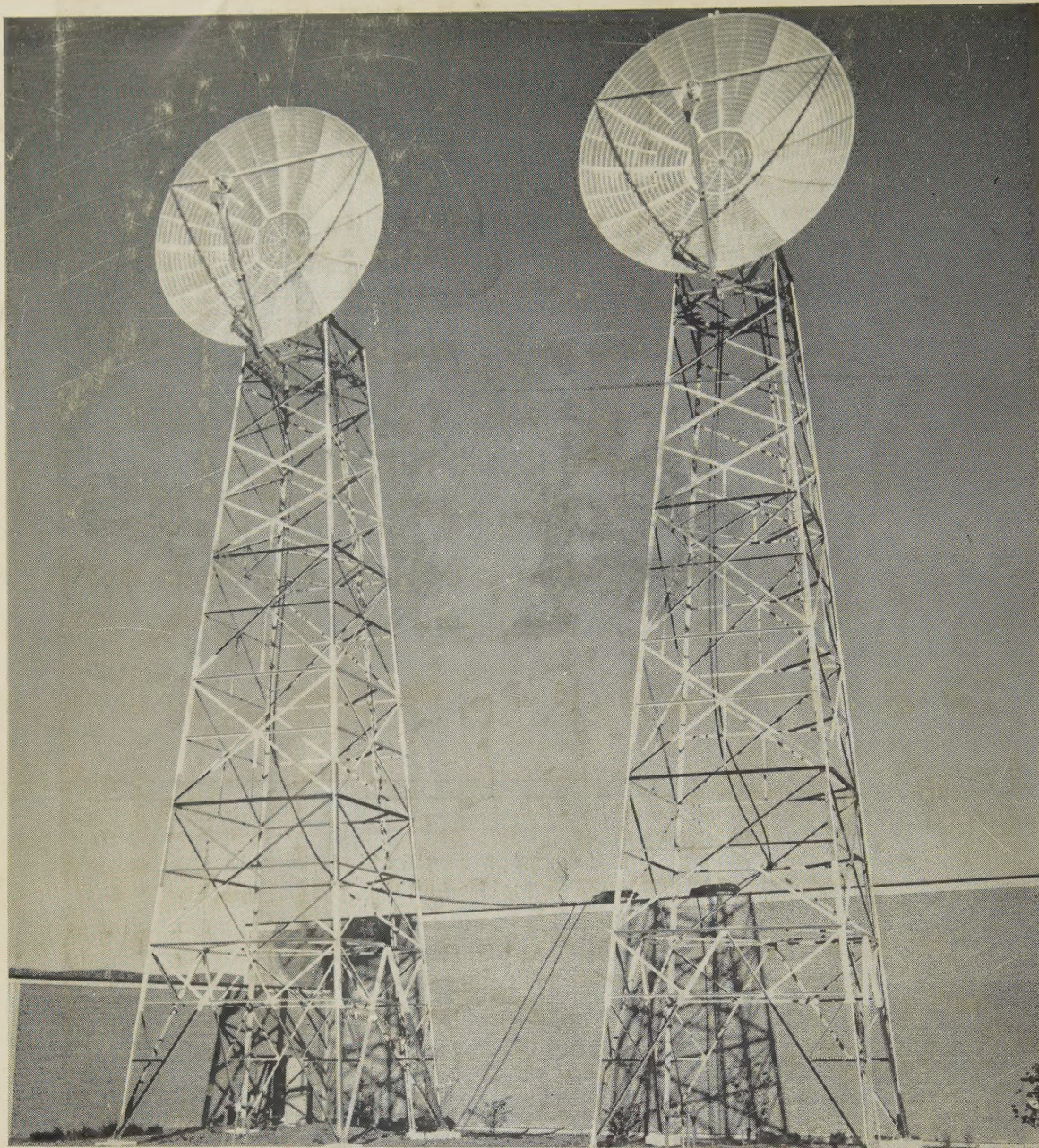
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